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ABSTRACT

This module is the fifth of nine modules in the competency-based Missouri Auto Mechanics Curriculum Guide. Seventeen units cover: steering system design; diagnosing steering systems problems; inspecting and replacing steering linkage components; manual and power steering gear service; manual and power rack and pinion steering gear service; power steering pump service and diagnosis; steering column inspection and repair; front suspension system design; suspension system diagnosis and lubrication; servicing conventional front suspension systems; Macpherson strut suspension service; wheel bearing and spindle service; design and operating principles of rear suspension system; air adjustable shock absorbers and electronic suspension controls; wheels and tires; wheel runout and balance; and wheel alignment and steering and suspension diagnosis. Introductory materials include a competency profile and cross-reference table that shows how competencies relate to instructional objectives, job sheets, assignment sheets, and test items. Each unit consists of some or all of these components: objective sheet with unit and specific objectives; cover sheet with content outline and list of references; information sheets; assignment sheets; job sheets; and unit test with answer key. (YLB)

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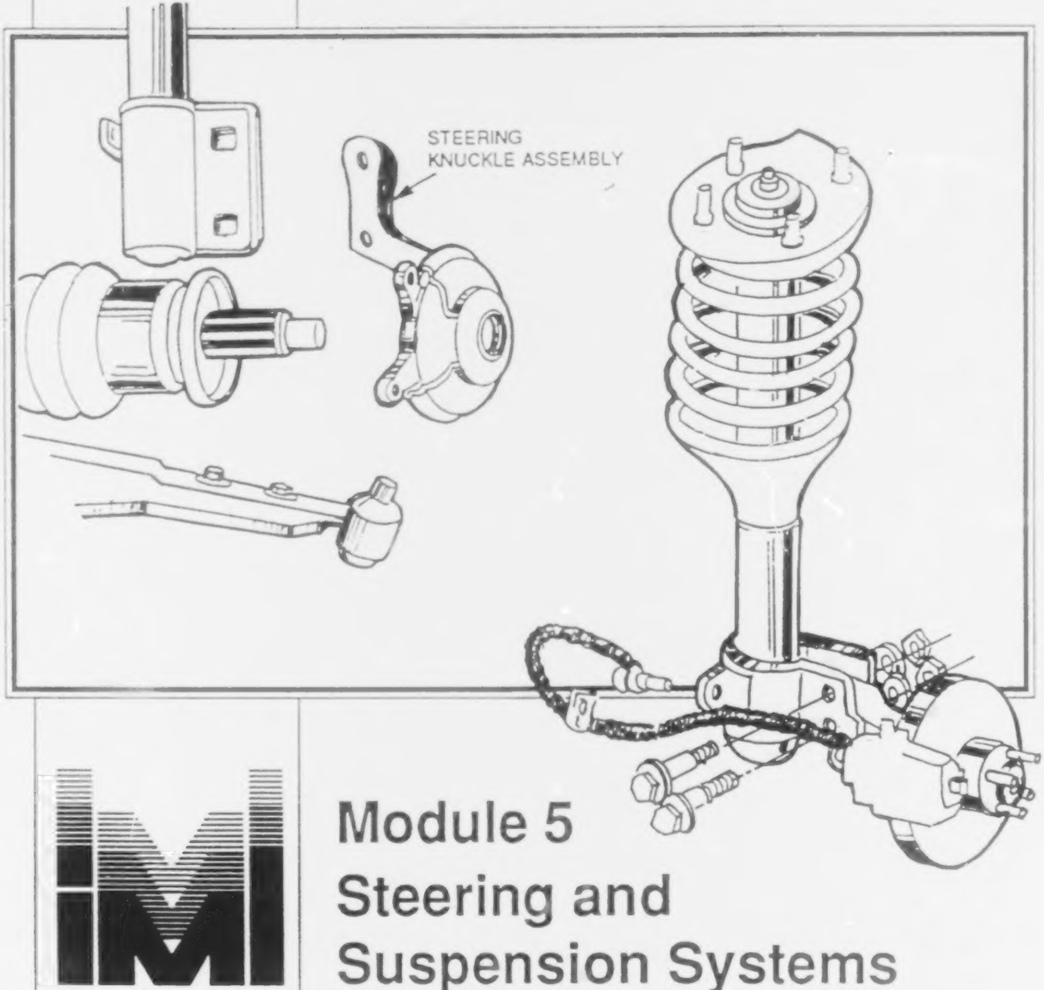
Instructor's Guide

Auto Mechanics
Curriculum Guide



Module 5
Steering and Suspension Systems

Produced by
Instructional Materials Laboratory
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Elementary and Secondary
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MODULES INCLUDED IN THE AUTO MECHANICS CURRICULUM GUIDE

INTRODUCTION TO AUTO MECHANICS
ELECTRICAL SYSTEMS
ENGINE PERFORMANCE
ENGINE REPAIR
STEERING AND SUSPENSION
BRAKES
MANUAL DRIVE TRAIN AND AXLES
AUTOMATIC TRANSMISSION AND TRANSAXLES
HEATING AND AIR CONDITIONING

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AUTO MECHANICS CURRICULUM

MODULE 5: STEERING AND SUSPENSION SYSTEMS

INSTRUCTOR'S GUIDE

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FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts, and professionalism to develop curriculum for trade, technical, and industrial education programs. The Steering and Suspension Systems module (the fifth of nine modules to make up the Missouri Auto Mechanics Curriculum Guide) is an outstanding example of what can be accomplished when the right people with the right attitude work together. The curriculum writers and subject matter experts who worked on this guide are to be commended for a job well done.

The module's format has been developed for competency-based teaching and testing. Job sheets within the guide evaluate specific competencies and can be managed with the Vocational Administrative Management System (VAMS). All major components of the module have been keyed to the Missouri Auto Mechanics Competency Profile, which was developed by industry and education professionals within Missouri.

Special appreciation is given to Larry Rains, the module's writer. Special appreciation is also given to Fred Smith, who served as a technical adviser during production of the module.

The format and curriculum management system found in this module may be new to many vocational educators. However, we are confident that, when used as designed, this module will allow for a more productive and rewarding educational experience for both teacher and student. Any future auto mechanics curriculum modifications will begin with the Missouri Auto Mechanics Curriculum Guide. Auto mechanics, like many technical fields, is undergoing constant and considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

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ACKNOWLEDGEMENTS

Steering and Suspension Systems is the fifth of nine modules that make up the Missouri Auto Mechanics Curriculum Guide. Produced by the Instructional Materials Laboratory (IML), the guide represents a continuing commitment to Missouri's Vocational Instructional Management System (VIMS). All modules in the guide are based on the Missouri Auto Mechanics Competency Profile, which in turn is based on and cross-referenced to the ASE task list. For years ASE has set the professional standards for automotive technicians. Therefore, a strong ASE orientation makes the guide an effective tool for preparing students to enter the technologically advanced field of auto mechanics.

IML extends special recognition to Larry Rains, the writer of Steering and Suspension Systems. Mr. Rains' years of experience as both a teacher and an automotive technician is evident throughout his work. Special recognition also goes to Fred Smith, who contributed heavily to the module as a technical adviser. Mr. Smith's attention to technical detail proved invaluable throughout the module's development.

IML gratefully acknowledges the important contribution of the advisory committee, which, among other tasks, developed the competency profile for the guide. The advisory committee members are listed below:

Advisory Committee Members

Charles Waibel and Judith Moore, Division of Vocational and Adult Education, Department of Elementary and Secondary Education, Jefferson City, Mo.
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Wayne Sweatt, Lake AVTS, Camdenton, Mo.
Darwin Kraenow, Linn Technical College, Linn, Mo.

IML also acknowledges the fieldtesters, who worked to ensure that the Steering and Suspension Systems module was developed into an effective and practical teaching tool. The fieldtesters are listed below:

Fieldtesters

Robert Barbarick, Four Rivers AVTS, Washington, Mo.
Robert Colesworthy, Lewis & Clark AVTS, St. Charles, Mo.
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IML would like to express special appreciation to Auffenberg's Eldon Ford-Mercury in Eldon, Mo. for providing access to their technical library.

The support and contributions of the following IML staff members were instrumental to the development of this module:

Instructional Materials Laboratory Staff

Harley Schlichting, Director
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Phyllis Miller, Assistant Director
Dan Stapleton, Assistant Director
Sharon Dyer, Graphic Artist II
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HOW TO USE THE MISSOURI AUTO MECHANICS CURRICULUM GUIDE

Every module of the Missouri Auto Mechanics Curriculum Guide contains the following seven major components: (1) a competency profile, (2) objective sheets, (3) information sheets, (4) assignment sheets, (5) job sheets, (6) tests, and (7) a cross-reference table. Below is a discussion of the design of these components.

MISSOURI COMPETENCY PROFILE

The competency profile identifies 144 basic auto mechanics competencies. The profile divides the competencies into nine general areas, each of which serves as the basis for individual modules of instruction (such as the Steering and Suspension Systems module). The competency profile further divides these general areas into duty bands, each of which is identified by a capital letter. An example of a duty band in the Steering and Suspension Systems module would be "Steering Systems." Under each duty band are listed several competencies, each of which is identified by an Arabic numeral. Note the below excerpt from the competency profile:

3	2	1	N	R. Steering Systems	ASE Task(s)
				1 Diagnose and determine needed repairs on steering systems	D002 D003 D013 D015 E049
				2 Clean and inspect power and manual steering gear boxes	D005 D006 D021
				3 Reassemble and adjust power and manual steering gear boxes	D007
				4 Clean and inspect power and manual rack-and-pinion steering rack	D008 D009 D012
				5 Reassemble and adjust power and manual rack-and-pinion steering rack	D010
				6 Inspect and repair steering columns	D001 D004
				7 Inspect and replace steering linkage components	D011 D022 D028
				8 Inspect and repair power steering pumps	D016 D020

In this excerpt, the duty band "Steering Systems" is identified by the letter "R." The competency "Inspect and replace steering linkage components" falls under Duty Band R and is identified by the Arabic numeral "7." Throughout the Steering and Suspension Systems module, therefore, the competency "Inspect and replace steering linkage components" will be referred to as Competency R7. Other competencies under Duty Band R are, for example, R1,"Diagnose and determine needed repairs on steering systems," and R2 "Clean and inspect power and manual steering gear boxes."

Also note that one or more ASE tasks are listed to the right side of each competency on the profile. These ASE tasks are directly related to those competencies by which the tasks appear.

(**NOTE:** The term "cross-reference table" will appear throughout the rest of this discussion. A cross-reference table is a chart that shows precisely how objectives, assignment sheets, test questions, and job sheets are related to individual competencies. The cross-reference table will be discussed later in more detail.)

INFORMATION SHEETS

The information sheets (or information outline) present the student with important facts and concepts relating to basic automotive technology and service procedures. The information sheets also explain why a procedure is necessary and why it must be performed in a certain manner. Though not intended to be as comprehensive as a textbook, the information sheets provide a good source of information to which the student can refer outside of class. Perhaps the information sheets can best be thought of as a thorough set of notes accompanying the instructor's classroom lecture.

ASSIGNMENT SHEETS

The assignment sheets serve one of two functions: they can either emphasize important cognitive information or instruct students in developing procedures specific to a particular vehicle. The "Notes to the Instructor," found on the table of contents section of each module, indicates how each assignment sheet is used.

(**NOTE:** Assignment sheets are not used to evaluate competencies directly. Only job sheets directly evaluate competencies.)

UNIT TESTS

Unit tests cover information relating to specific competencies. The student must obtain acceptable test scores (decided upon by the instructor) before receiving an evaluation for these competencies. (Since job sheets are used to evaluate competencies, the student, therefore, must receive an acceptable test score before doing certain job sheets.) The test ensures that the student has the minimum knowledge required to perform the competencies covered on the job sheets. On some tests, all the questions cover information that relates equally to a single competency or group of competencies. At the end of the tests a note like the following appears.

> (NOTE: The student must obtain a minimum score of ____ on the Unit III Test in order to receive an evaluation for Competency R7.)

On other tests, one group of questions covers information related exclusively to one competency or a group of competencies while another group of questions relates exclusively to another competency or group of competencies. Questions relating to a specific competency or group of competencies are divided into parts. At the end of each part, a note like the following appears:

> (NOTE: The student must obtain a minimum score of ____ on Part III of the Unit V Test in order to receive an evaluation for Competency R7.)

All the test questions and job sheets related to each competency are listed on the module's cross-reference table. The cross-reference table allows the instructor to determine what test questions a student must successfully complete before being eligible to perform the job sheets related to a particular competency. By observing the test notes and using the cross-reference table, the instructor can easily determine what job sheets a student is eligible to do as a result of his or her score on a test or a particular part of a test.

OBJECTIVE SHEETS

The first page of each unit in the guide is an objective sheet, which states the unit's general and specific objectives. Below is a partial reproduction of the objective sheet for Unit V of the Steering and Suspension Systems module:

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT V: MANUAL AND POWER RACK AND PINION STEERING GEAR SERVICE

UNIT OBJECTIVE

After completing this unit, the student should be able to service and adjust manual and power rack and pinion steering gears. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify the procedures for inspecting the tie rods on rack and pinion steering assemblies (Competency R7, Part III of the Unit V Test).

II. Identify the procedures for removing and installing a manual rack and pinion steering gear (Competency R4, Part I of the Unit V Test).

III. Identify the procedures for disassembling and inspecting a manual rack and pinion steering gear (Competency R4, Part I of the Unit V Test).

IV. Identify the procedures for reassembling the manual rack and pinion steering gear (Competencies R4, R5, and R7, Parts I, II, and III of the Unit V Test).

V. Demonstrate the ability to:

- a. Remove and install a manual rack and pinion steering gear (Competency R4, JS1-L1-UV).
- b. Inspect and replace rack and pinion inner tie rods and bellows boots (Competency R7, JS2-L1-UV).
- c. Disassemble, clean, and inspect a manual rack and pinion steering gear (Competency R4, JS3-L1-UV).
- d. Reassemble and adjust a manual rack and pinion steering gear (Competency R4, JS4-L1-UV).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D008–D012.

Notice that the specific objectives are designated by Roman numerals. Also notice that the competency (or competencies) to which each objective relates is listed in parentheses behind each objective. Also listed in parentheses is the method by which the student's ability to perform the objective is evaluated.

A note identifying the ASE tasks that are covered by the unit's job sheets appears at the end of every objective sheet.

JOB SHEETS

Besides giving the student practical, hands-on experience in auto mechanics, job sheets provide a means of evaluating a student's ability to perform the competencies. The job sheets are, therefore, the key component of the Missouri Auto Mechanics Curriculum Guide. Below is an excerpt from the first page of a typical job sheet in the Steering and Suspension and Systems module:

JS2-L1-UV

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING RACK AND PINION INNER TIE RODS AND BELLOWS BOOTS

Equipment:

Hand tools
Torque wrench
Serviceable vehicle
Hoist
Specialty tools
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Place the vehicle securely on safety stands or lift it with a hoist. ___ ___ ___ ___

   (**CAUTION:** Always use proper equipment when lifting a vehicle.)

3. Complete AS2-L1-UV. Following the procedure developed in item 2 of AS2-L1-UV, inspect the condition of the inner tie rods and bellows boots. Record observations. ___ ___ ___ ___

4. If required, follow the procedure developed in item 3 of AS2-L1-UV to remove the inner tie rod and bellows boot. ___ ___ ___ ___

   (NOTE: It may be necessary to remove the rack and pinion unit before removing the inner tie rod and bellows. If so, refer to JS1-L1-UV for the procedure.)

5. Following the procedure developed in item 4 of AS2-L1-UV, install the inner tie rods and bellows boots. Also perform the tasks outlined below. ___ ___ ___ ___

   a. Be sure to retain the inner tie rods in the factory-recommended manner.

   b. Tighten all fasteners to specified torque.

Notice that the job sheet is identified as JS2-L1-UV, which translates into Job Sheet 2, Lesson 1, Unit V. This shorthand system of job sheet identification is used throughout the curriculum guide.

(**NOTE:** Assignment sheets are identified with the same shorthand system. Assignment Sheet 1, Lesson 1, Unit III would be AS1-L1-UIII.)

(**NOTE:** Both job sheets and assignment sheets are numbered consecutively within unit lessons.)

Also notice that, in the above job sheet excerpt, the spaces to the right of the page allow the instructor to evaluate the student on a particular job sheet activity. These spaces appear only by numbered items, which represent significant tasks; therefore, the instructor is freed from having to evaluate the minor steps of a procedure. At the beginning of each job sheet, the heading "3 2 1 N" indicates the four possible evaluations a student can receive. The meaning of the numbers and the letter N is as follows:

3 = Mastery - can work independently with no supervision
2 = Requires supervision - can perform job completely with limited supervision
1 = Not mastered - requires instruction and close supervision
N = No exposure - no experience or knowledge in this area

The individual evaluations made throughout a job sheet are averaged together at the end of the job sheet. A note at the end of the job sheet explains how this average relates to the final evaluation for a particular competency. Shown below is the note found at the end of JS3-L2-UV. The note explains that the average of the individual evaluations made throughout the job sheets is the final evaluation for Competency R5:

Average of above evaluations* — — — —

(*This average is the final evaluation for Competency R5.)

As automotive instructors know, an automobile contains many complex and interrelated components. A single general service task may involve several different procedures. In the Missouri Auto Mechanics Curriculum Guide, therefore, a competency may be evaluated over several job sheets; also one job sheet may evaluate several competencies. As will be demonstrated later, each job sheet is accompanied by a thorough set of instructions, explaining how each of the final job sheet averages is to be used. The cross-reference table is also quite helpful in showing which job sheets evaluate which competencies.

CROSS-REFERENCE TABLE

The cross-reference table can quickly reveal how competencies relate to instructional objectives, job sheets, and test items. Note the following excerpt from the Steering and Suspension Systems module cross-reference table:

MODULE: STEERING AND SUSPENSION SYSTEMS
CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
R7	UI-L1-I, UI-L1-III, UI-L1-IV, UIII-L1-I, UIII-L1-II, UIII-L1-III, UIII-L2-I, UIII-L2-II, UIII-L2-III, UIII-L2-IV, UIII-L2-V, UIII-L2-VI, UIII-L2-VII, UIII-L2-VIII, UIII-L2-IX, UV-L1-I, UV-L1-IV, UV-L2-III	AS1-L1-UI AS1-L2-UI AS1-L2-UIII AS2-L2-UIII AS3-L2-UIII AS2-L1-UV	JS1-L2-UIII JS2-L2-UIII JS3-L2-UIII JS4-L2-UIII JS5-L2-UIII JS6-L2-UIII JS7-L2-UIII JS2-L1-UV	UI 1-45 UIII 1-25 UV 27-35	

The above excerpt lists all the instructional objectives in the module that cover Competency R7. The cross-reference table also indicates the test questions that cover Competency R7. Just as importantly, the table reveals at a glance that the student must perform JS1-L2-UIII, JS2-L2-UIII, JS3-L2-UIII, JS4-L2-UIII, JS5-L2-UIII, JS6-L2-UIII, JS7-L2-UIII, and JS2-L1-UV before he or she can receive an evaluation for Competency R7. By looking at the cross-reference table, the instructor can, therefore, quickly determine what test questions a student needs to answer and what job sheets a student needs to perform before receiving a final evaluation for a particular competency.

HOW AND WHY COMPETENCIES ARE EVALUATED OVER SEVERAL JOB SHEETS

According to the competency profile, Competency R7 "Inspect and replace steering linkage components" covers eight ASE tasks. A job sheet covering all of these ASE tasks would be unreasonably long and overly complicated. As was indicated above, the Missouri Auto Mechanics Curriculum Guide allows the student to perform several job sheets in order to receive an evaluation for Competency R7. These job sheets are listed below:

JS1-L2-UIII:	Inspecting and Replacing a Pitman Arm
JS2-L2-UIII:	Inspecting and Replacing a Center Link
JS3-L2-UIII:	Inspecting and Replacing Tie Rods
JS4-L2-UIII:	Inspecting and Replacing an Idler Arm
JS5-L2-UIII:	Inspecting and Replacing a Steering Dampener
JS6-L2-UIII:	Inspecting and Replacing a Power Steering Control Valve on a Linkage-Type Power Steering System
JS7-L2-UIII:	Inspecting and Replacing a Power Cylinder on a Linkage-Type Power Steering System
JS2-L1-UV:	Inspecting and Replacing Rack and Pinion Inner Tie Rods and Bellows Boots

The activities in the above job sheets satisfy Missouri Competency R7 and the ASE tasks that accompany R7. At the end of each job sheet relating to R7, a note explains that the individual evaluations made throughout the job sheet are averaged together to determine a partial evaluation for R7. The note also indicates on what job sheet the final evaluation for R7 will be determined. Below is an example of the note found at the end of JS1-L2-UIII:

Average of above evaluations* ____

(*This average is a partial evaluation for Competency R7. Final evaluation for R7 will be made at the end of JS2-L1-UV.)

At the end of JS2-L1-UV, the following note is found:

Average of above evaluations* ____

(*This average is a partial evaluation for Competency R7. Final evaluation for R7 will be made below.)

Also at the end of JS2-L1-UV, the following instructions explain how the final evaluation for R7 is to be made:

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency R7 by averaging the evaluations of JS1-L2-UIII, JS2-L2-UIII, JS3-L2-UIII, JS4-L2-UIII, JS5-L2-UIII, JS6-L2-UIII, JS7-L2-UIII, and JS2-L1-UV. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L2-UIII	__	__	__	__
JS2-L2-UIII	__	__	__	__
JS3-L2-UIII	__	__	__	__
JS4-L2-UIII	__	__	__	__
JS5-L2-UIII	__	__	__	__
JS6-L2-UIII	__	__	__	__
JS7-L2-UIII	__	__	__	__
JS2-L1-UV	__	__	__	__
Final evaluation for Competency R7	__	__	__	__

The content of the Steering and Suspension Systems module is organized in the most teachable manner possible; therefore, content relating to Competency R7 is covered in both Unit III and Unit V. The job sheets evaluating R7, therefore, appear in all two of these units rather than being grouped together. Again, the job sheet notes and the cross-reference table make it easy to identify and assign the job sheets that relate to a specific competency.

Some job sheets in the Steering and Suspension Systems module cover more than one competency. For example, JS1-L2-UX, "Inspecting and Replacing Coil Springs," covers Competencies S1 and S2. Shown below is the note for JS1-L2-UX:

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competencies S1 and S2. Final evaluations for S1 will be made at the end of JS5-L2-UX. Final evaluation for S2 will be made at the end of JS4-L2-UX.)

Job sheet notes sometimes vary to reflect the content of the job sheet. The information in the note, however, is always presented in a straight-forward, easy-to-understand manner.

PACKAGING OF THE AUTO MECHANICS CURRICULUM GUIDE

Each module in the Auto Mechanics Curriculum Guide is packaged in three components: an instructor's guide, a student reference, and student work sheets. The instructor's guide includes the following items, all of which are color coded:

Cross-reference table (color-coded white)
Objective sheets (color-coded white)
Table of contents, references, notes to the instructor, answer sheets for assignment sheets and tests (color-coded pink)
Information sheets (color-coded green)
Assignment sheets (color-coded tan)
Job sheets (color-coded blue)
Unit tests (color-coded yellow)

The student reference contains copies of the objective sheets and information sheets from the instructor's guide. The student work sheets include consumable items from the instructor's guide, such as job sheets, assignment sheets, and unit tests. For convenience, the page numbers of the items in the student reference and in the work sheets are the same as those in the instructor's guide; therefore, page numbers in the student reference and work sheets are not consecutive. All student reference pages and work sheet pages are white.

Competency profiles for the guide are packaged in groups of ten along with a copy of the ASE task list.

MODULE: STEERING AND SUSPENSION SYSTEMS
CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
R1	UI-L1-I, UI-L1-II, UII-L1-I, UII-L1-II UII-L1-III, UII-L1-IV, UII-L1-V, UII-L2-I, UII-L2-II, UII-L2-III, UII-L2-IV, UII-L3-I, UII-L3-II, UII-L3-III, UII-L3-IV, UII-L3-V	AS1-L1-UI AS1-L2-UI AS1-L1-UII	JS1-L1-UII JS2-L1-UII JS1-L2-UII JS1-L3-UII	UI 1-45 UII 1-30	
R2	UI-L1-I, UI-L1-II, UI-L2-I, UI-L2-II, UI-L2-IV, UI-L2-V, UI-L2-VI, UIV-L1-I, UIV-L1-II, UIV-L2-I, UIV-L2-II	AS1-L1-UI AS1-L2-UI AS1-L1-UIV AS2-L1-UIV AS1-L2-UIV AS2-L2-UIV	JS1-L1-UIV JS2-L1-UIV JS1-L2-UIV JS2-L2-UIV	UI 1-45 UIV 1-21	
R3	UI-L1-I, UI-L1-II, UI-L2-I, UI-L2-II, UI-L2-IV, UI-L2-V, UI-L2-VI, UIV-L1-III, UIV-L2-III, UIV-L2-IV	AS1-L1-UI AS1-L2-UI AS3-L1-UIV AS3-L2-UIV	JS3-L1-UIV JS3-L2-UIV	UI 1-45 UIV 22-38	
R4	UI-L1-I, UI-L1-V, UI-L2-II, UI-L3-I, UI-L3-II, UV-L1-II, UV-L1-III, UV-L1-IV, UV-L2-I, UV-L2-II, UV-L2-III	AS1-L1-UI AS1-L2-UI AS1-L3-UI AS1-L1-UV AS3-L1-UV AS1-L2-UV AS2-L2-UV	JS1-L1-UV JS3-L1-UV JS4-L1-UV JS1-L2-UV JS2-L2-UV	UI 1-45 UV 1-16	
R5	UI-L1-I, UI-L1-V, UI-L2-II, UI-L3-I, UI-L3-II, UV-L1-IV, UV-L2-III	AS1-L1-UI AS1-L2-UI AS1-L3-UI AS3-L2-UV	JS3-L2-UV	UI 1-45 UV 17-26	
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Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
R7	UI-L1-I, UI-L1-III, UI-L1-IV, UIII-L1-I, UIII-L1-II, UIII-L1-III, UIII-L2-I, UIII-L2-II, UIII-L2-III, UIII-L2-IV, UIII-L2-V, UIII-L2-VI, UIII-L2-VII, UIII-L2-VIII, UIII-L2-IX, UV-L1-I, UV-L1-IV, UV-L2-III	AS1-L1-UI AS1-L2-UI AS1-L2-UIII AS2-L2-UIII AS3-L2-UIII AS2-L1-UV	JS1-L2-UIII JS2-L2-UIII JS3-L2-UIII JS4-L2-UIII JS5-L2-UIII JS6-L2-UIII JS7-L2-UIII JS2-L1-UV	UI 1-45 UIII 1-25 UV 27-35	
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S2	UVIII-L1-I, UVIII-L1-II, UVIII-L2-I, UVIII-L2-IV, UVIII-L2-V, UVIII-L2-VI, UVIII-L3-I, UVIII-L3-II, UIX-L1-II, UIX-L1-III, UX-L2-I, UX-L2-II, UX-L2-III, UX-L2-IV, UX-L2-V, UX-L2-VI, UX-L2-VII	AS1-L1-UVIII AS1-L2-UVIII AS2-L1-UIX AS1-L2-UX AS2-L2-UX AS3-L2-UX AS4-L2-UX	JS2-L1-UIX JS3-L1-UIX JS1-L2-UX JS2-L2-UX JS3-L2-UX JS4-L2-UX	UVIII 1-50 UIX 11-25 UX 1-30	
S3	UVIII-L1-I, UVIII-L1-II, UVIII-L2-I, UVIII-L2-IV, UVIII-L2-V, UVIII-L2-VI, UVIII-L3-I, UVIII-L3-II, UXII-L1-I, UXII-L1-II, UXII-L1-III, UXII-L1-IV, UXII-L1-V, UXII-L1-VI	AS1-L1-UVIII AS1-L2-UVIII AS1-L3-UVIII AS1-L1-UXII AS2-L1-UXII AS3-L1-UXII	JS1-L1-UXII JS2-L1-UXII JS3-L1-UXII	UVIII 1-50 UXII 1-20	

Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
S4	UVIII-L1-I, UVIII-L1-II, UVIII-L2-I, UVIII-L2-IV, UVIII-L2-V, UVIII-L2-VI, UX-L1-I, UX-L1-II	AS1-L1-UVIII AS1-L2-UVIII	JS1-L1-UX JS2-L1-UX	UVIII 1-50 UX 31-45	
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T2	UXIII-L2-I UXIII-L2-IV UXIV-L2-I, UXIV-L2-II, UXIV-L2-III	AS1-L1-UXIII AS1-L2-UXIII	JS1-L2-UXIII JS4-L2-UXIII JS1-L2-UXIV	UXIII 27-38 UXIV 21-35	
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Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
U1	UXV-L1-I, UXV-L1-II, UXV-L1-III, UXV-L1-IV, UXV-L1-V, UXV-L1-VI, UXV-L1-VII, UXV-L1-VIII, UXV-L1-IX, UXV-L2-I, UXVII-L1-I, UXVII-L1-II, UXVII-L1-III, UXVII-L1-IV, UXVII-L1-V, UXVII-L1-VI, UXVII-L1-VII, UXVII-L1-VIII	AS1-L2-UXVI AS1-L1-UXVII	JS1-L2-UXV JS1-L2-UXVI JS1-L1-UXVII	UXV 1-24 UXVII 1-20	
U2	UIX-L1-I, UXVII-L2-I, UXVII-L2-II, UXVII-L3-I, UXVII-L3-II, UXVII-L3-III, UXVII-L3-IV, UXVII-L3-V, UXVII-L3-VI, UXVII-L3-VIII	AS1-L1-UIX AS1-L2-UXVII AS1-L3-UXVII	JS1-L1-UIX JS1-L3-UXVII	UIX 1-10 UXVII 21-40	
U3	UXVII-L2-I, UXVII-L2-II, UXVII-L3-I, UXVII-L3-II, UXVII-L3-III, UXVII-L3-VII, UXVII-L3-VIII	AS1-L2-UXVII AS2-L3-UXVII	JS2-L3-UXVII	UXVII 41-45	
U4	UXV-L2-II, UXV-L2-III, UXV-L2-IV, UXV-L3-I, UXV-L3-II, UXV-L3-III, UXVI-L1-I, UXVI-L1-II, UXVI-L2-I, UXVI-L2-II, UXVI-L2-III, UXVI-L2-IV, UXVI-L2-V	AS1-L2-UXV AS1-L2-UXVI	JS2-L2-UXV JS1-L3-UXV JS2-L3-UXV JS2-L2-UXVI	UXV 25-45 UXVI 1-35	

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT I: STEERING SYSTEM DESIGN

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the components and operating principles of different types of steering systems. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with steering systems (Competencies R1-R8, Unit I Test).

II. Identify conventional steering system components for manual and power systems (Competencies R1-R3, Unit I Test).

III. Identify linkage components (Competency R7, Unit I Test).

IV. Identify the basic steering linkage designs used on manual and power steering systems (Competency R7, Unit I Test).

V. Identify power and manual rack and pinion steering components (Competencies R4 and R5, Unit I test).

Lesson 2.

I. Identify manual steering gear components (Competencies R2 and R3, Unit I Test.)

II. Identify the principles of hydraulics (Competencies R2-R5 and R8, Unit I Test).

III. Identify the operating principles of the power steering pump (Competency R8, Unit I Test).

IV. Identify the operating principles of the integral rotary valve power steering system (Competencies R2 and R3, Unit I Test).

V. Identify the operating principles of the integral gear spool valve and pivot lever power steering system (Competencies R2 and R3 Unit I Test).

VI. Identify the operating principles of the linkage type power steering system (Competencies R2 and R3, Unit I Test).

Lesson 3.

I. Identify the operating principles of the manual rack and pinion steering system (Competencies R4 and R5, Unit I Test).

II. Identify the operating principles of the power rack and pinion steering system (Competencies R4 and R5, Unit I Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material that is preliminary to ASE tasks appears in this unit; therefore, no ASE tasks are covered directly.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT I: STEERING SYSTEM DESIGN

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A. Objective sheet

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D. Lesson plans

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      AS1-L1-UI: Types of Steering Systems

  2. Lesson 2: CONVENTIONAL STEERING SYSTEM COMPONENTS AND THEIR FUNCTIONS

    a. Information outline

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      AS1-L2-UI: Functions of Conventional Steering System Components

  3. Lesson 3: MANUAL AND POWER RACK AND PINION STEERING COMPONENTS AND OPERATION

    a. Information outline

    b. Assignment sheet

      AS1-L3-UI: Rack and Pinion Components

E. Unit test

F. Answers to unit test

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Toboldt, William K. and Johnson, Larry. Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair. South Holland, Illinois: The Goodheart-Willcox Company, Inc. 1981.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L1-UI, AS1-L2-UI, and AS1-L3-UI before taking the Unit I Test.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

   1. Steering and Suspension-Front-End Types (AM-83-270), 1983.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT I: STEERING SYSTEM DESIGN

LESSON 1: INTRODUCTION TO THE STEERING SYSTEM

I. Terms and definitions

A. Ball socket--In a steering system, a moveable joint that tilts and rotates. The ball socket consists of a stud with a ball on one end. The ball fits securely in a socket assembly.

B. Center link (also known as a drag link or relay rod)--A rod that transfers motion from the pitman arm to the left and right tie rods. The center link is held in position by the idler arm.

C. Control valve--A valve assembly that controls the flow of pressurized power steering fluid to the power cylinder.

D. Idler arm--An arm that is attached to the vehicle frame on one end and to the steering linkage on the other. The idler arm supports the center link and allows the steering motion to be directed to the tire rods.

E. Pitman arm--The connecting link between the steering gear and the center link.

F. Power cylinder--A hydraulic cylinder attached to the steering linkage. When pressurized, the power cylinder assists the driver in turning the wheels.

G. Power steering--A steering system that uses hydraulic pressure to make steering easier.

H. Steering pump--A hydraulic pump that pressurizes and circulates power steering fluid. The pump is usually driven by a belt running from the crankshaft pulley to another pulley attached to the pump shaft.

I. Rack and pinion steering--A steering gear with a pinion gear attached to the steering shaft. The pinion gear runs in a rack (a long bar with gear teeth), which is attached to the wheels by tie rod assemblies.

J. Steering column--An assembly that contains the steering shaft. (The steering shaft connects the steering wheel and steering gear.) The steering column is mounted under (and usually supported by) the instrument panel. The steering column may contain portions of the gear shift mechanism and/or electrical wiring for various components.

K. Steering dampener--An assembly that resembles a shock absorber in appearance and operation.

L. Steering gears (also known as steering gear box)--The gears mounted in a housing at the lower end of the steering column. Steering gears reduce the effort needed to turn the steering wheel.

M. Steering knuckle--The inner portion of the spindle. The steering knuckle is supported by and pivots on either the upper and lower ball joints or a king pin. The steering knuckle may either be an integral part of the spindle or simply bolted to it.

N. Tie rod assembly--A term used to describe the tie rod ends and adjuster sleeve.

O. Tie rod adjuster sleeve--A split tube with internal threads. The tie rod adjuster sleeve connects two tie rods and allows for toe settings. The tie rod adjuster sleeve is held in place with clamps.

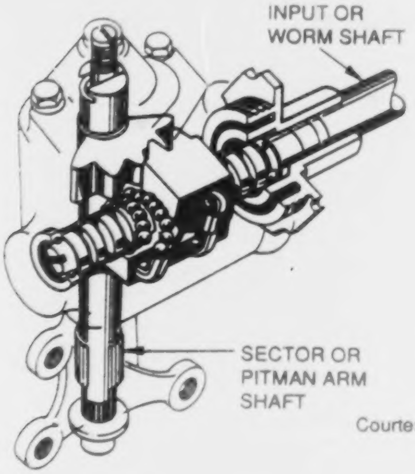
P. Tie rod end--A ball socket assembly that is connected to a steering knuckle or center link.

II. Conventional steering system components for manual and power systems

A. Manual steering gear

1. Most manual steering gears are of the recirculating ball nut design. This design uses steel balls between a worm gear and a rack gear, which is machined into a ball nut. The steel balls act as a rolling thread to provide minimum friction when turning.

2. The average gear ratio of a manual steering gear is about 24 to 1. At this ratio, the steering wheel and steering shaft, which are coupled to the worm gear shaft, must turn 24 times in order to turn the output or sector shaft once. Such a large ratio greatly reduces the effort required to turn the steering wheel.

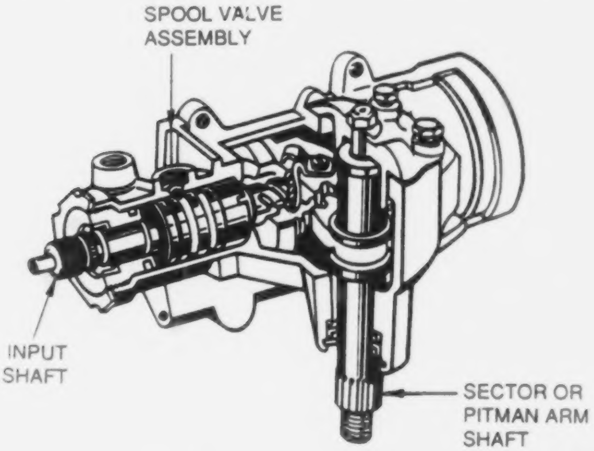


Courtesy of Moog Automotive, Inc.

B. Integral power steering

1. The typical integral power steering gear has many components similar to those in a manual steering gear. Both use a worm shaft and a sector or pitman shaft. Many integral power steering gears use a recirculating ball nut similar to those in the manual gear.

2. A unique component of the power steering gear, however, is a hydraulic power piston and a control valve. The power piston uses hydraulic oil pressure to provide most of the force needed to turn the wheels. The average power steering gear ratio is about 15 to 1. This ratio provides the driver with quicker turning response. If the hydraulic steering system should fail or if the engine should stall, the driver will still be able to steer the vehicle, although doing so will require extra effort.

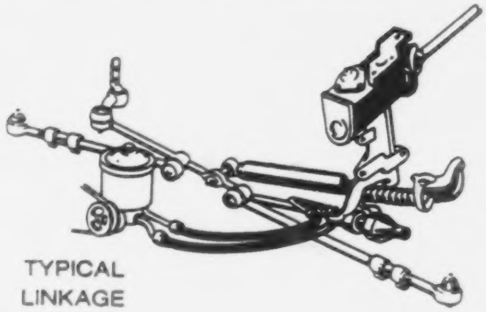


Courtesy of Moog Automotive, Inc.

C. Linkage-type power steering

1. A linkage-type power steering system uses an external, double-acting hydraulic cylinder and control valve. One end of the cylinder is attached to the steering linkage under the vehicle, the other end attached to the vehicle's frame.

2. When the steering wheel is turned, the hydraulic cylinder is pressurized and provides some of the force needed to turn the wheels. The linkage-type power steering utilizes a manual style steering gear box. If the pump or some other part of the hydraulic steering system should fail or if the engine should stall, the driver will still be able to steer the vehicle, although doing so will require extra effort.



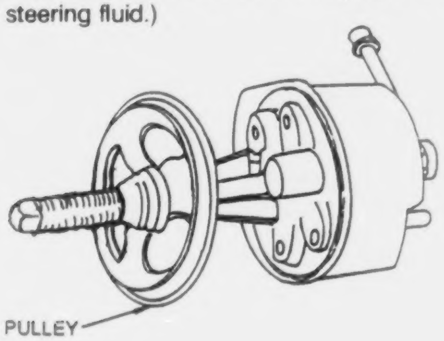
Courtesy of Moog Automotive, Inc.

D. Power steering pump

1. The power steering pump pressurizes and circulates power steering fluid. The three common types of power steering pumps are the vane, the roller, and the slipper. All three types are similar in operation. These pumps will be covered in more detail later in this unit.

2. The power steering pump is normally driven by a V-belt or a V-ribbed belt. Power steering pumps are capable of producing pressure in the range of 1000 to 1500 psi. The power steering pump should never run when the fluid level is significantly low. The power steering fluid should, therefore, be checked regularly.

(NOTE: Most late-model vehicles with power steering require the use of approved power steering fluid.)



E. Power steering hoses transfer hydraulic pressure from the power steering pump to the gear assembly and back to the pump. Power steering hoses are usually constructed of reinforced synthetic rubber or a similar material. The hoses are coupled to metal tubing at connecting points.

(**CAUTION:** Always wear eye protection to protect eyes from pressurized oil. Always use a hose capable of handling system pressure.)

III. Linkage components

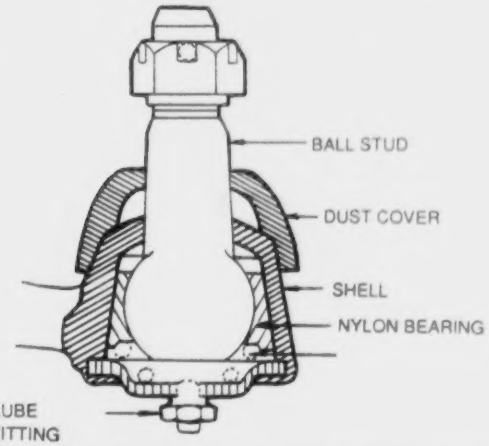
A. Tie rod ends

1. A conventional tie rod end consists of a tapered ball stud that is inserted in a steel or nylon bearing socket. A spring or plastic spacer holds the ball in position in the socket.

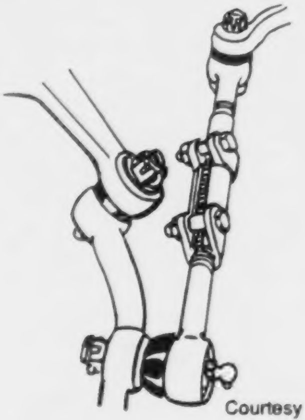
2. A forged outer shell encases the socket assembly. Some outer shells have a threaded hole that accepts grease fittings for lubrication. In other cases, the sockets are lubed and sealed during assembly and require no additional lubrication. A threaded rod is an integral part of the outer shell. The rod may have right- or left-handed threads, depending on its location in the steering linkage. A rubber dust cover fits over the ball stud and shields the ball socket from dirt and moisture. Ball sockets similar to those used in tie rod ends are sometimes used at other steering linkage connecting points.

B. A rubber bonded socket tie rod end consists of a tapered ball stud with a molded rubber element on one end and a tie rod housing on the other. The stud is pressed into the housing; a lip is rolled over to hold the housing in place. The rubber element's tight fit prevents it from turning in the socket. The joint has no moving surfaces and, therefore, requires no lubrication. The joint moves as a result of the rubber element's twisting action.

TIE ROD END



C. A tie rod sleeve is an internally threaded tube, which screws over and connects two tie rod ends. The tie rod sleeve is threaded with left-handed threads on one end and right-handed threads on the other. Turning the sleeve will move the tie rod ends closer together or farther apart, thus providing a means for toe adjustment. The ends of the sleeve are split and surrounded by a clamp. When tightened, the clamp squeezes the sleeve and holds it in position on the tie rod end.

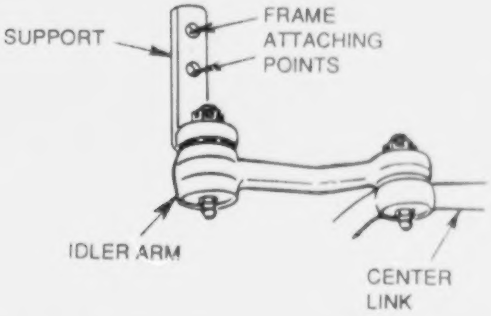


Courtesy of Moog Automotive, Inc.

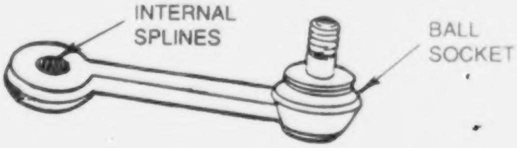
D. Idler arm

1. One type of idler arm uses a metal and rubber bushing assembly. A steel outer shell is press fit in the idler arm. A rubber insert is bonded to the inside of the outer shell and to a steel sleeve inside the rubber insert. This assembly is bolted securely to the idler arm support bracket through the inner sleeve. When the steering linkage moves, the rubber insert twists in the metal shell. The idler arm may attach to the steering linkage through another bushing arrangement or a ball socket.

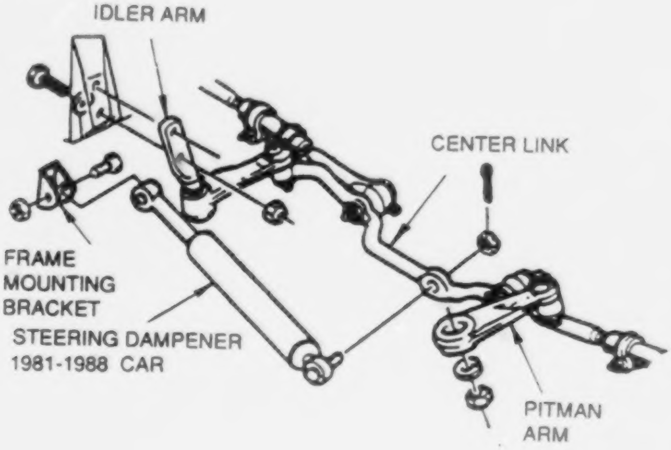
2. Another type of idler arm has a threaded bushing arrangement. The lower end of the support for this idler arm has external threads, which match internal threads in the arm. Linkage movement causes the arm to turn on the threads. A grease fitting is provided for lubrication.


SUPPORT
FRAME ATTACHING POINTS
IDLER ARM
CENTER LINK

E. The pitman arm is splined at one end to the sector shaft and held in place with a hex nut or pinch bolt. The other end is attached to the center link by a ball and a socket. The ball and socket may be on the pitman arm or the center link.

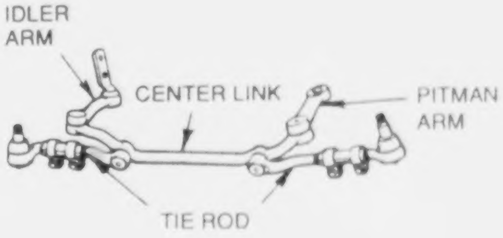

INTERNAL SPLINES
BALL SOCKET

F. Some vehicles use a steering dampener to absorb steering wheel oscillations (shimmy). The dampener can be installed during manufacture or added later. The dampener is mounted from the vehicle frame to the steering linkage. Mounting hardware includes rubber grommets, which reduce noise and vibration. The dampener uses a rod with a piston attached to one end. The piston travels back and forth in an oil-filled cylinder as the vehicle's wheels are turned. Special orifices allow oil to flow in and out of the piston chambers at a controlled rate, thus preventing the steering linkage from moving rapidly back and forth.

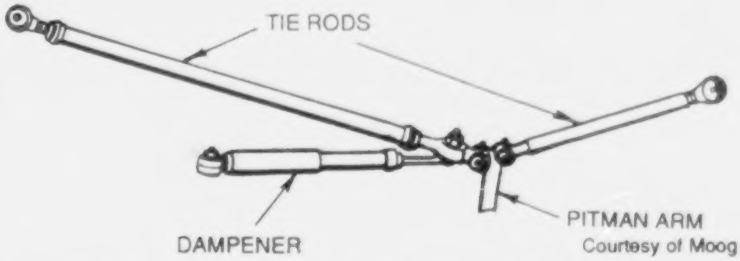

IDLER ARM
CENTER LINK
FRAME MOUNTING BRACKET
STEERING DAMPENER 1981-1988 CAR
PITMAN ARM

IV. Linkage designs

A. The parallelogram linkage design uses two tie rod assemblies of equal length, a pitman arm, an idler arm, and a center link. The parallelogram is the most commonly used linkage design.

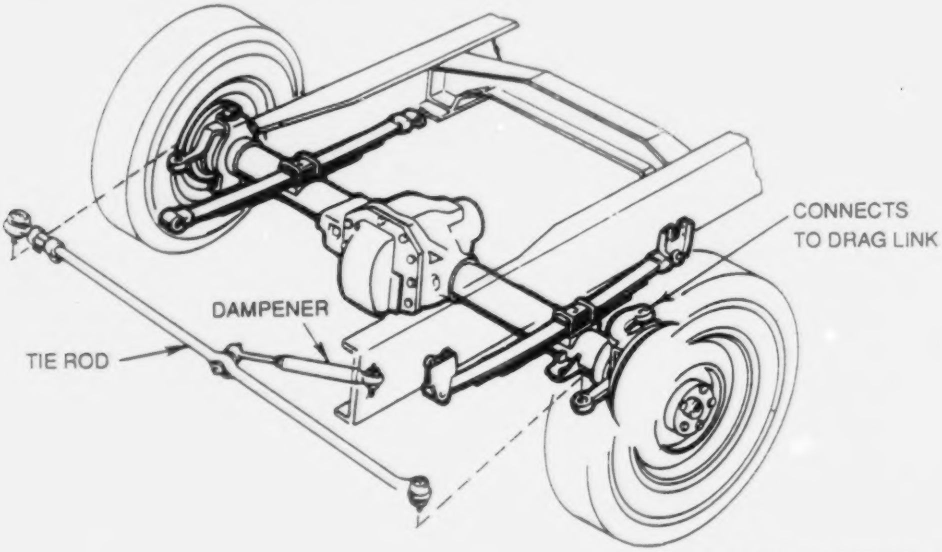

IDLER ARM
CENTER LINK
PITMAN ARM
TIE ROD

B. The center point linkage design consists of one long and one short tie rod assembly with a center steering (pitman) arm. A steering dampener is used in center point linkage designs.


TIE RODS
DAMPENER
PITMAN ARM

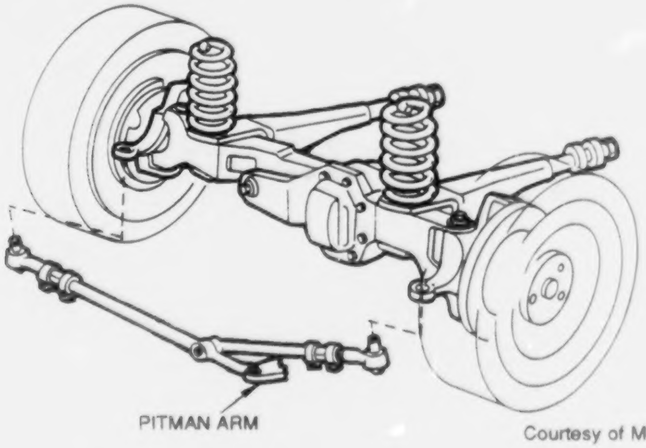
Courtesy of Moog Automotive, Inc.

C. Truck straight axle and four-wheel-drive axle steering linkage designs commonly use one long tie rod assembly, which connects to both steering knuckles. A second arm can be found on the rear of the left steering knuckle. A drag link (short tie rod assembly) connects this second arm to the pitman arm. A truck straight axle and four-wheel-drive axle steering linkage sometimes includes a dampener.


CONNECTS TO DRAG LINK
DAMPENER
TIE ROD

Courtesy of Moog Automotive, Inc.

D. The twin I-beam axle steering linkage design uses a long tie rod assembly that runs from the pitman arm to the right steering knuckle. A shorter tie rod assembly extends from a point on the longer tie rod to the left knuckle.



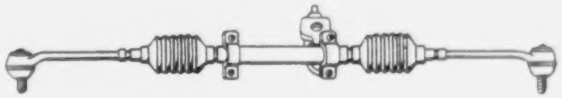
Courtesy of Moog Automotive, Inc.

V. Rack and pinion steering components (manual and power steering)

A. Manual rack and pinion steering consists of a pinion gear, which meshes with a long rack gear. When the steering wheel is turned, the pinion drives the rack to the left or right. Inner and outer tie rod assemblies connect the rack to the wheels. Rack and pinion steering offers several advantages, which are listed below.

1. The rack and pinion steering system is relatively smaller than conventional systems and thus weighs less. The rack and pinion's small size is also well-suited to today's smaller cars.

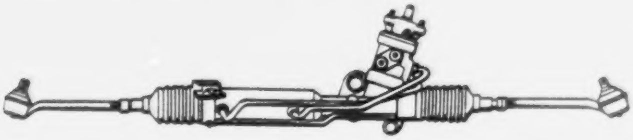
2. In rack and pinion systems, the steering gear is located under the car (instead of in the engine compartment), thus providing more room in the engine compartment.



Courtesy of Moog Automotive, Inc.

B. A power rack and pinion steering system functions much like a manual system. The power system, however, integrates a double-acting power piston into the rack. A valve on the pinion gear shaft controls fluid flow. The power rack and pinion steering system is also compact and lightweight. However, the system's housing must be larger to accommodate the extra power-assistance components.

(NOTE: The pump used to operate a power rack and pinion steering unit is similar to one used by conventional power steering systems.)



Courtesy of Moog Automotive, Inc.

MODULE: STEERING AND SUSPENSION SYSTEMS

TYPES OF STEERING SYSTEMS

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. What type of gear design is commonly used in manual steering systems?

2. Name two basic power steering system designs.

3. Power steering pumps can produce what range of pressure?

4. What is the average power steering gear ratio?

5. Name the three most common types of power steering pumps.

MODULE: STEERING AND SUSPENSION SYSTEMS

TYPES OF STEERING SYSTEMS

(ANSWER SHEET)

1. Recirculating ball nut design
2. integral and linkage
3. 1000 to 1500 psi
4. 15 to 1
5. The vane, roller, and slipper pumps

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT I: STEERING SYSTEM DESIGN

LESSON 2: CONVENTIONAL STEERING SYSTEM COMPONENTS AND THEIR FUNCTIONS

I. Manual steering gear components

A. The worm shaft and recirculating ball nut assembly is the input shaft of the steering gear. Adjustable ball thrust bearings support the worm shaft and recirculating ball nut assembly in the gear housing.

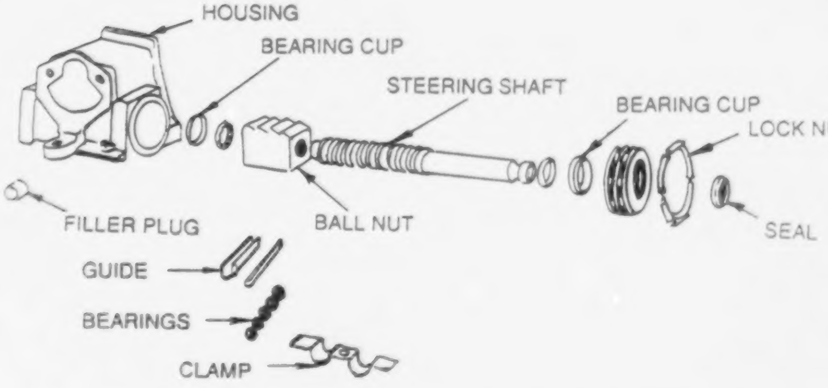
1. The inner surface of each thrust bearing is machined into the worm shaft as are special spiral grooves. These grooves are used in place of the teeth found on a common worm gear. The grooves provide a rolling surface for the steel balls in the ball nut.

2. Splines on the worm shaft's upper or exposed end connect the worm shaft to the steering shaft, usually through a flexible coupling.

3. The recirculating ball nut assembly works much like a common nut in that as the worm shaft is turned, the ball nut is screwed up or down the shaft. The recirculating ball nut differs from a common nut in the ways described below.

a. Instead of conventional threads, the ball nut has internal grooves, which match the external worm shaft grooves. Steel balls roll in these grooves, thus resulting in a rolling thread.

b. Manual steering gears generally have two sets of balls (containing about 20 to 30 balls per set). Each set rolls in its individual circuit, which consists of the ball nut and worm shaft grooves and special tubes called ball return guides. These guides are attached to the outside of the nut.



c. If the steering wheel is turned to the left, the worm shaft also turns. As a result, the balls roll through their circuit between the worm shaft and ball nut, which, in turn, moves the ball nut up or down the shaft.

d. As the balls roll to the end of the ball nut, they move through a drilled passage and enter a ball return guide (located on the outside of the nut). Upon leaving the return guide, the balls re-enter the nut through another drilled passage and can thus repeat the circuit.

e. If the steering wheel was turned to the right, the balls would circulate in the opposite direction, causing the ball nut to move in the opposite direction on the worm shaft.

(NOTE: The recirculating ball nut assembly creates less friction, resulting in easier steering and less steering gear wear.)

B. The sector shaft serves as the output shaft of the steering gear. The sector shaft's rotary motion is transferred directly to the steering linkage via the pitman arm. (The sector shaft is also referred to as a pitman shaft.)

1. The sector shaft is made of heavy steel and is supported in the gear housing by needle bearings or bronze bushings pressed into the gear housing. Splines are machined into the output end of the sector shaft; the output end is also threaded below the splines. The pitman arm fits tightly onto the splines and is held firmly in place by a nut screwed onto the threads. A sector gear (a special coarse-toothed gear) is an integral part of the sector shaft. The sector gear meshes with the rack teeth on the ball nut.

a. The sector shaft is not required to make a complete revolution; the shaft must move only far enough to cause adequate lateral pitman arm movement to steer the vehicle. Therefore, only a few sector gear teeth surround the circumference of the sector shaft.

b. The sector gear teeth are slightly tapered; the gear lash (clearance) between the sector gear and the sector shaft can be adjusted by raising or lowering the sector shaft in its housing. The upper end of the sector shaft has a slot in which an adjusting screw is attached. This screw is threaded into a portion of the gear housing. Turning the screw changes the gear mesh.

2. When the steering wheel is turned, the worm shaft also turns, causing the ball nut to move. Upon moving, the ball nut's rack teeth exert force against the sector shaft teeth, causing the sector shaft to rotate.

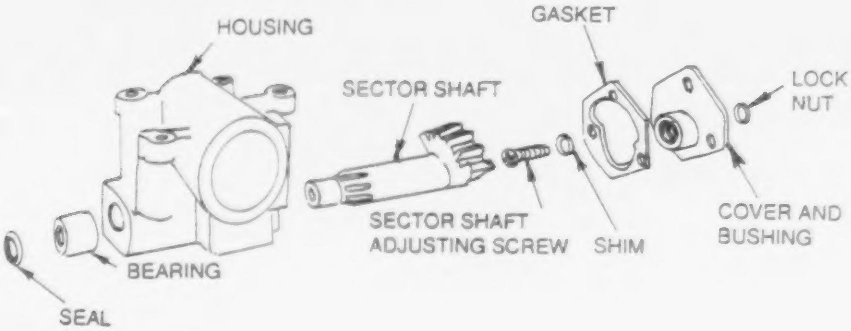
C. The gear housing is usually made from either die-cast aluminum or cast iron. The housing holds and supports both the worm shaft and the sector shaft. Lubricant is also contained within the housing.

1. Most gear housings have a machined opening for bearing cups and bushings, which are used in the worm and sector shafts. Cap screws hold a sector shaft cover to the gear housing. This cover conceals an opening through which the sector shaft can be removed. The sector shaft cover contains a bearing or bushing that also supports the sector shaft. A threaded hole in the cover accepts the sector shaft adjusting screw.

2. A threaded hole in the gear housing (opposite the worm shaft bearing cup) allows for removal of the worm shaft. The worm shaft bearing adjuster screws into this hole. The adjuster contains the second worm shaft bearing cup, which is held in place by a press fit. The worm shaft bearing adjuster is usually found on the upper end (or steering shaft end) of the gear housing; however, the adjuster is sometimes located on the opposite end.

3. A seal in the gear housing retains oil at the sector shaft. Another oil seal is located either in the gear housing or worm shaft adjuster at the worm shaft opening.

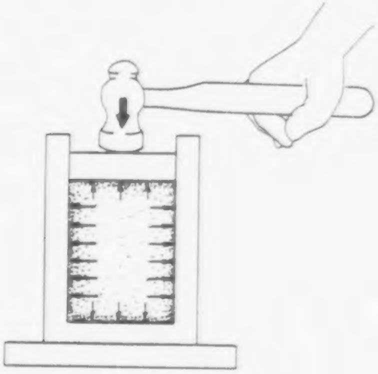
4. The gear housing is bolted to the vehicle's frame. The steering gear assembly is usually designed so that the sector shaft is positioned vertically. In some assembly designs, the sector shaft is positioned horizontally.



II. Principles of hydraulics

A. Pascal's Law

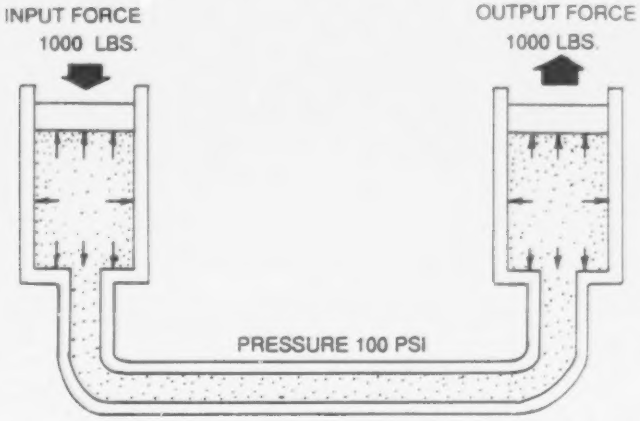
1. According to Pascal's Law, liquids (unlike gases) cannot be compressed. Pressure applied to a confined liquid is transmitted equally and undiminished in all directions. Liquid under pressure, therefore, can be used much like a mechanical lever.



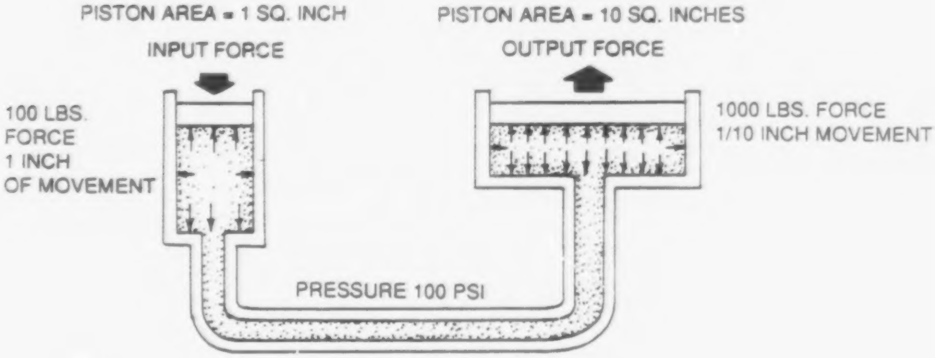
2. Pascal's Law defines pressure as force divided over the area where it is distributed. Pressure is measured in pounds per square inch (psi) or kilopascals (kp).

B. Pascal's Law in relation to fluid motion and multiplying force

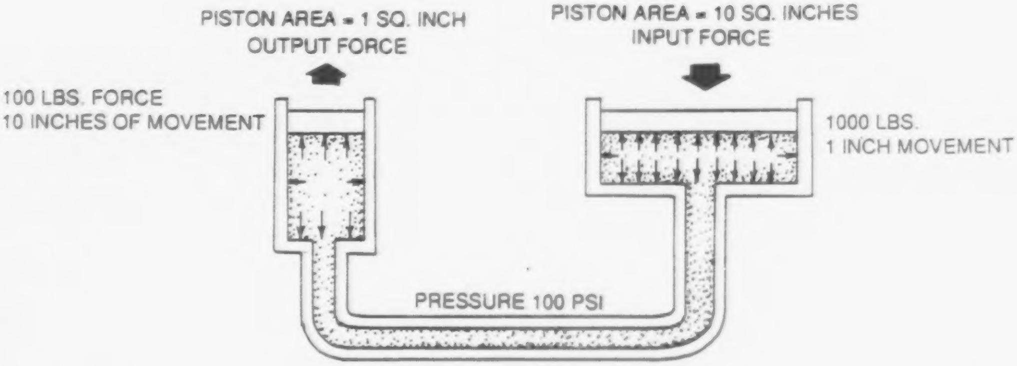
1. In systems where the input and output pistons are the same size, the force and motion generated by the input piston will be equal to the force and motion generated by the output piston.


INPUT FORCE
1000 LBS.
OUTPUT FORCE
1000 LBS.
PRESSURE 100 PSI

2. In systems where the input piston is smaller than the output piston, force will be multiplied and the motion of the output piston will decrease.


PISTON AREA = 1 SQ. INCH
INPUT FORCE
PISTON AREA = 10 SQ. INCHES
OUTPUT FORCE
100 LBS.
FORCE
1 INCH
OF MOVEMENT
1000 LBS. FORCE
1/10 INCH MOVEMENT
PRESSURE 100 PSI

3. In systems where the input piston is larger than the output piston, force will be decreased and the motion of the output piston will increase.


PISTON AREA = 1 SQ. INCH
OUTPUT FORCE
PISTON AREA = 10 SQ. INCHES
INPUT FORCE
100 LBS. FORCE
10 INCHES OF MOVEMENT
1000 LBS.
1 INCH MOVEMENT
PRESSURE 100 PSI

4. The distance that the output piston travels is inversely proportional to its surface area (as the surface area compares to the input piston).

C. Pascal's Law applies to the power steering system. The power steering pump transfers the hydraulic pressure through a hose or line in order to move the power piston. In other words, the power steering pump converts mechanical force from the vehicle's engine into hydraulic force and transfers it to the power piston; by its movement, the power piston thus converts the hydraulic force back to mechanical force. Because force moves through liquid undiminished, the pump can move the piston with great efficiency.

III. Power steering pump

A. As was stated above, the power steering pump converts mechanical force from the vehicle's engine into hydraulic pressure, which reduces the effort required to turn the steering wheel. The vane, the roller, and the slipper are three types of power steering pumps commonly used on today's vehicles. All three pumps function in a similar manner.

B. Power steering pump components

1. The pump housing contains the entire pump assembly with the exception of the fluid reservoir. The housing supports the input shaft on a bushing, which is pressed into the housing's shaft bore. An oil seal at the shaft bore prevents the escape of fluid. Threaded mounting holes in the housing allow the pump to be attached to the vehicle. A separate rear cover, which is held in place by cap screws or a retaining ring, encloses the back opening of the housing.

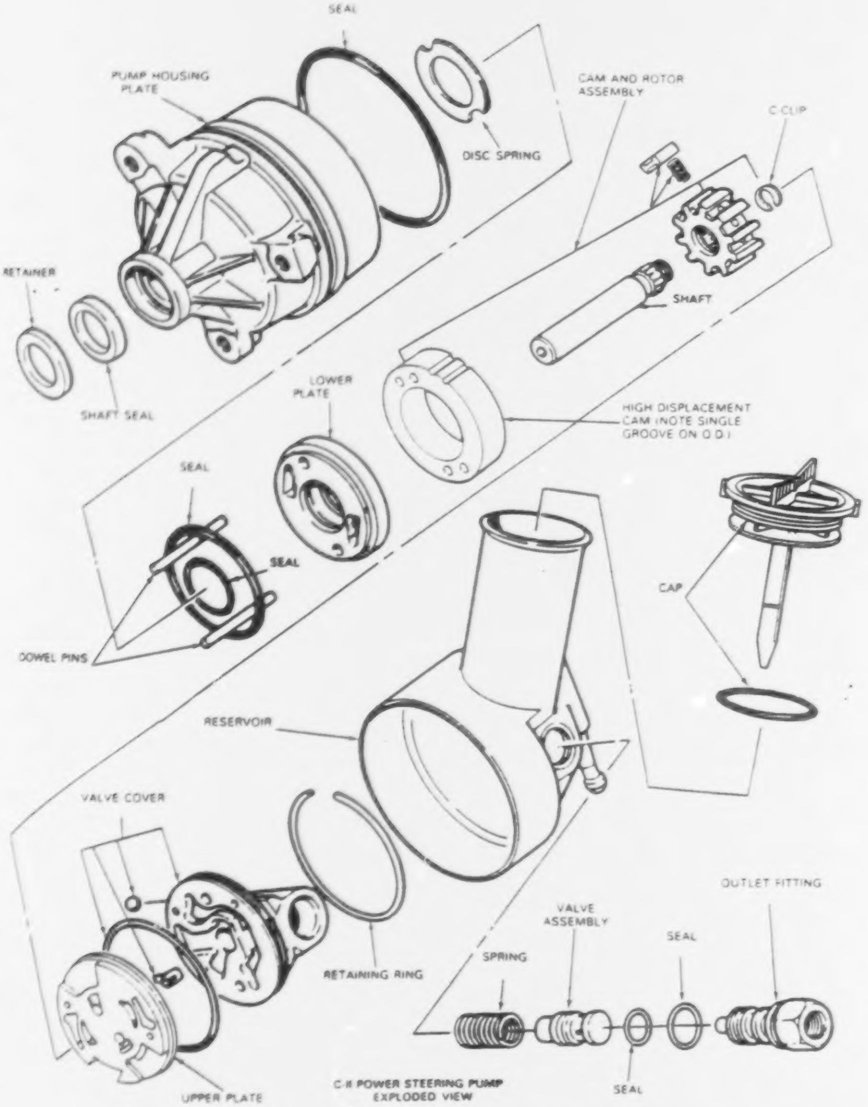
2. The steel pump shaft is supported in the pump housing by a bronze bushing. A pulley is attached to the portion of the shaft extending outside the pump. The pulley is either press fit between the shaft and pulley or threaded onto the end of the shaft with a shaft key and nut.

3. The pump's rotor is attached to the portion of the shaft located inside the housing. The rotor is either press fit to the shaft or connected to it by splines and a retaining ring. Either vanes, spring-loaded slippers, or steel rollers are contained in each of the slots or grooves around the rotor's circumference.

4. The pump's cam ring is a steel plate with a cam-shaped (or eccentrically shaped) center hole. The rotor turns inside the cam ring; the action of the vanes running against the cam's surface draws hydraulic fluid from the pump reservoir. The pump then discharges the fluid under pressure.

(NOTE: A pump using slippers or rollers in the rotor produces similar results.)

5. The pump's pressure plate, constructed of flat, ground-steel, is located against the sides of the cam ring. The pressure plate retains the fluid in the cam ring; the plate also has special passages that direct fluid in and out of the cam ring/rotor assembly. Steel dowel pins hold the cam ring and pressure plates in position. A spring behind the rear pressure plate holds the cam ring and pressure plate assembly firmly together.


SEAL
PUMP HOUSING PLATE
DISC SPRING
CAM AND ROTOR ASSEMBLY
C-CLIP
RETAINER
SHAFT
SHAFT SEAL
LOWER PLATE
HIGH DISPLACEMENT CAM (NOTE SINGLE GROOVE ON O.D.)
SEAL
SEAL
DOWEL PINS
CAP
RESERVOIR
VALVE COVER
OUTLET FITTING
VALVE ASSEMBLY
SEAL
SPRING
RETAINING RING
UPPER PLATE
SEAL

C-II POWER STEERING PUMP EXPLODED VIEW

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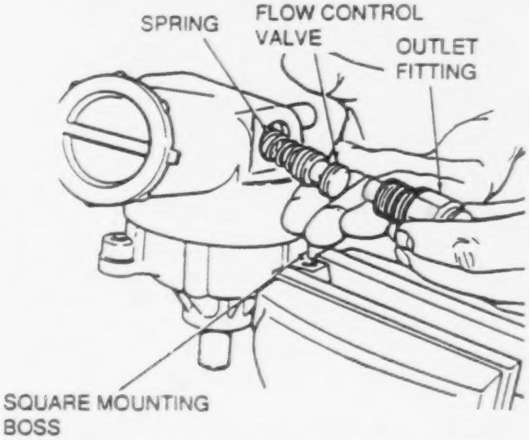
6. The pump's flow control valve (a spool valve) reduces the amount of fluid that the pump delivers to the steering gear assembly during excessive pump output (such as might occur during high-speed driving, for example). The valve, therefore, reduces fluid temperatures and conserves engine power. Spring pressure in the valve reduces fluid flow. With the engine running and no pressure demand from the gear, the pump flow overcomes the spring pressure and opens the valve.

a. An orifice (a small hole) directs a metered amount of fluid from the pump to the spring side of the flow valve. As pump output increases, so does pressure on the spring side of the valve; thus, a regulated flow from the pump is maintained. The pressure is always lower on the spring side of the pump due to a pressure drop, which occurs as fluid travels through the orifice.

b. The flow control valve includes a built-in pressure relief valve, which limits pump output pressure to a predetermined level. When the predetermined level is reached (during parking, for example), a steel ball lifts off its seat against spring pressure, sending fluid back into the reservoir until output pressure is acceptable.



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7. Constructed of either stamped steel or fiberglass- reinforced nylon, the pump reservoir is usually fitted over the outer circumference of the pump housing. The reservoir is usually held in place by studs or bolts. A rubber o-ring seals the pump to the reservoir. Most reservoirs have a dipstick attached to the reservoir fluid filler cap.

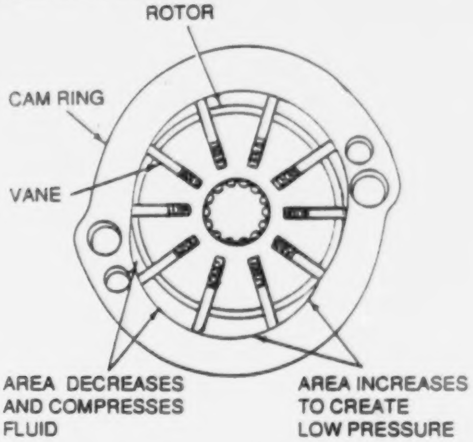
(NOTE: On some pumps, the reservoir is mounted at a remote location above the pump. A hose connects the reservoir to the pump inlet.)

C. Operation of the vane power steering pump

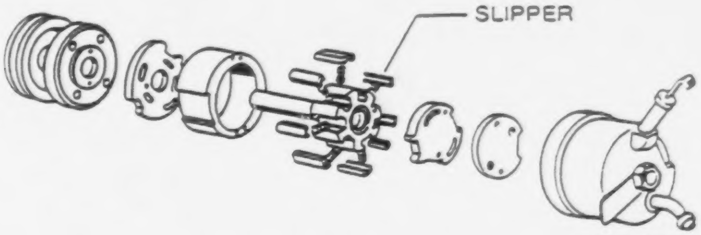
1. As the rotor begins to turn, centrifugal force moves the vanes out against the cam ring. The vanes will form spaces between the rotor and the cam ring. Fluid is drawn from the pump's intake port into these spaces.

2. The spaces between the rotor and cam ring become smaller as the rotor continues to turn. The fluid in the spaces is, therefore, pressurized and forced out through discharge ports in the pressure plate.

3. As pressure starts to build in the pump, pressurized fluid is directed under each vane in the rotor slots, forcing the vanes tight against the inside oval surface of the cam ring. The pressurized fluid is then directed through the flow control valve and discharged from the pump.

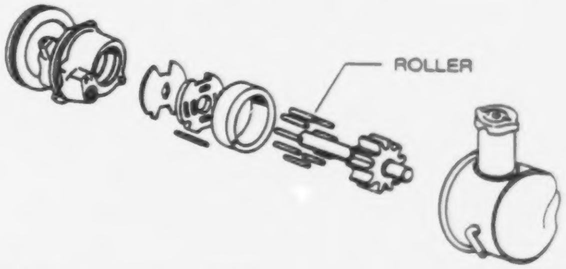

ROTOR
CAM RING
VANE
AREA DECREASES AND COMPRESSES FLUID
AREA INCREASES TO CREATE LOW PRESSURE

D. Slipper power steering pumps operate in basically the same manner as vane pumps. In the slipper pump, however, spring-loaded slippers (not rectangular vanes) ride against the cam ring.



Courtesy of Moog Automotive, Inc.

E. Roller power steering pumps operate in basically the same manner as vane pumps. In the roller pump, however, steel rollers fit into each rotor segment and move out against the cam ring as the rotor turns.



Courtesy of Moog Automotive, Inc.

IV. Rotary valve integral power steering system

A. Operation of the rotary valve integral power steering system

1. Many power steering gears use a recirculating ball nut similar to those found in manual steering gears. The hydraulic power piston is an integral part of the recirculating ball nut.

2. The power piston travels in a machined bore within the gear housing. The piston and gear housing allows pressurized fluid to reach either side of the piston. A teflon sealing ring is fitted into a ring groove, which is machined into the piston's outer circumference. The ring acts as a seal between the piston and housing. A rubber o-ring is installed under the teflon ring to reinforce the seal. When the rotary control valve admits pressurized fluid to the piston nut, hydraulic force is applied to one of the piston surfaces. This force assists in moving the piston nut up or down the worm shaft.

3. Unlike nonpower steering units, the worm shaft does not extend through the end of the steering gear case. A stub shaft connects the worm gear to the steering wheel and steering shaft via a flexible coupling at the base of the steering column.

4. The stub shaft extends into the steering gear housing and is connected to the worm shaft by a torsion bar. (A torsion bar is a spring steel rod, one end of which is anchored while the other end is free to twist.)

5. Some manufacturers make the ball groove more shallow toward the worm shaft's center; doing so allows for a slight preload to the balls between the worm and piston nut while the steering wheel is in the straight-ahead position. This design (referred to as high center) gives the vehicle more steering stability. Other manufacturers achieve steering stability by providing a tighter fit between the rack and sector gear.

6. The worm shaft receives end thrust as the rack piston moves up or down. Thrust bearings on both ends of the worm shaft control the end thrust.

B. Gear housing of the integral rotary valve power steering system

1. The sector shaft, piston-ball nut, and worm shaft are all contained in the gear housing. In some cases, the housing also contains the rotary control valve assembly; in others, a separate control valve housing attaches directly to the upper end of the gear housing. The gear housing supports the stub shaft with a bearing, which is located at either the upper end of the gear housing or at the control valve housing.

2. A fluid seal is located at both the stub shaft opening and the sector shaft. Most gear housings have a double seal arrangement at the sector shaft. The gear housing must be filled with fluid at all times. In addition to providing lubrication, the fluid absorbs road shocks and vibration, which might affect the steering gear. A check valve, located in the inlet pressure port of the gear housing, reduces steering wheel kickback.

    a. Kickback occurs when a bump in the road knocks the vehicle's front tires in an undesirable direction. Kickback can be transferred from the tires, through the steering linkage, into the steering gear and finally up to the steering wheel.

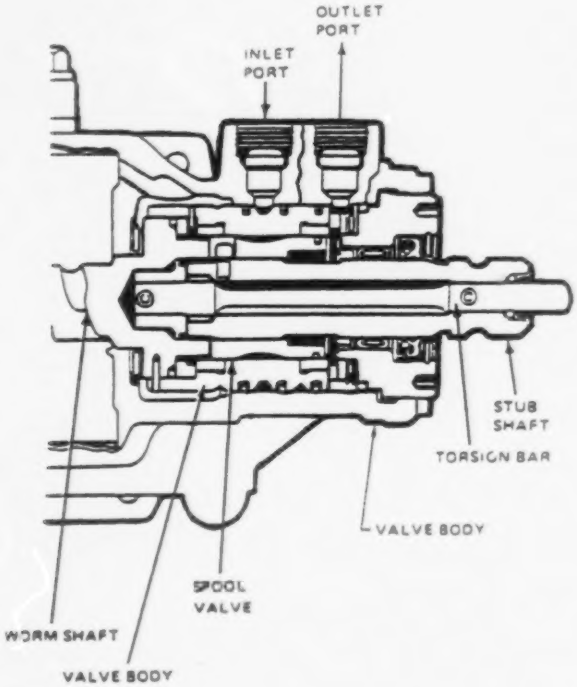
    b. Upon reaching the power piston, kickback will attempt to force surrounding fluid back through the rotary control valve and out of the pressure port. If the fluid were forced back, the steering wheel would move abruptly in the driver's hands. The check valve located in the gear housing pressure port prevents fluid from being forced back.

C. In the integral rotary valve power steering system, the sector shaft is integral with the sector gear. The design and function of the sector shaft differs little from manual steering gear sector shafts.

D. The rotary valve

1. In the integral rotary valve power steering system, the rotary valve directs the pressurized fluid to the proper side of the power piston during turning; the valve also stops fluid flow to the rack piston when no power assistance is needed. The valve is located in the upper (or input) end of the gear housing. Some gear designs contain the control valve in the main gear housing while others have a separate control valve housing, which is bolted to the main gear housing. With the exception of a pressure line reaching from the pump to the gear inlet and back, neither design uses any exterior fluid lines.

2. The twisting of a torsion bar opens and closes the valve.

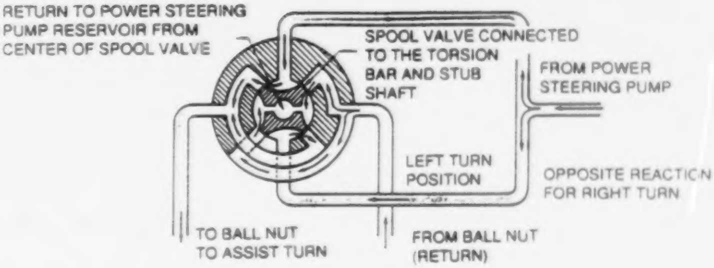


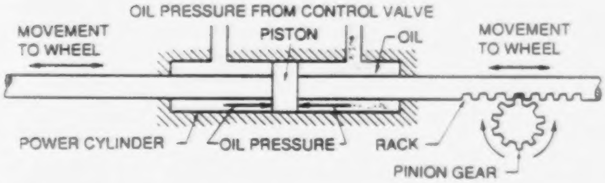
3. The rotary valve assembly pictured above consists of a stub shaft, valve body, valve spool, valve body cap, and worm shaft. A torsion bar connects all these components. Outlined below is a description of the valve's operation.

   a. The stub shaft (which attaches to the steering wheel through the steering shaft) is attached to the valve spool by a pin through the stub shaft's outside diameter. The stub shaft's outer end is attached to the torsion bar by a pin. The valve body is pinned to the body cap and torsion bar. Finally, the worm shaft is pinned to the valve body.

b. When the driver turns the steering wheel, the torsion bar twists. The twisting force acts upon the stub shaft. This force, however, is resisted by the vehicle's weight; the force is then transferred from the wheels, through the steering linkage, to the sector gear, to the piston nut, and finally to the worm gear.

c. Because the worm gear is resisting the turning force applied by the driver, the torsion bar twists, causing the stub shaft and valve spool (located inside the valve's body) to rotate. The valve spool's rotation directs fluid to one side of the piston nut, thus assisting the driver in turning the steering wheel. The harder the driver turns the steering wheel, the more the valve opens. The twisting action of the torsion bar allows the driver a feel for the road. The amount the torsion bar can twist is limited by two tangs attached to the upper end of the worm shaft. These tangs fit through slots in the valve body cap and stub shaft.


RETURN TO POWER STEERING PUMP RESERVOIR FROM CENTER OF SPOOL VALVE
SPOOL VALVE CONNECTED TO THE TORSION BAR AND STUB SHAFT
FROM POWER STEERING PUMP
LEFT TURN POSITION
OPPOSITE REACTION FOR RIGHT TURN
TO BALL NUT TO ASSIST TURN
FROM BALL NUT (RETURN)


OIL PRESSURE FROM CONTROL VALVE
MOVEMENT TO WHEEL
PISTON
OIL
MOVEMENT TO WHEEL
POWER CYLINDER
OIL PRESSURE
RACK
PINION GEAR

(NOTE: If the engine stalls, or power steering pressure is lost, the slots and tangs will still contact, thus providing manual steering.)

4. The interaction between the valve body and the valve spool (rotating inside the body) opens and closes passages and thereby directs fluid flow.

a. The valve body has two large grooves machined into its outer diameter. In the gear housing, one of the grooves lines up with the inlet pressure port while the other connects with a gear housing passage that directs fluid to the right turn chamber. The grooves are four holes drilled into the inside diameter of the valve body. The grooves are sealed with teflon rings, which are inserted in the valve body's ring grooves.

b. Eight slots are machined into the inside diameter of the valve body. Four are connected to the pressure groove by four of the holes drilled through the valve body. The other four slots are connected to the return port in the gear housing through the valve spool.

c. Within the valve body, four more holes direct fluid through a gear housing passage to the left turn chamber.

d. The valve spool fits very tightly inside the valve body, thus eliminating the need for sealing rings.

e. Four holes in the valve spool line up with the four return slots in the valve body. Fluid flows through the return slots, through the valve spool holes, then through the spool's center, and finally reaches the housing's return port.

f. The valve spool's outer diameter has eight slots. When the steering wheel is moved, these slots open either the right or left holes to the pressure or return slots.

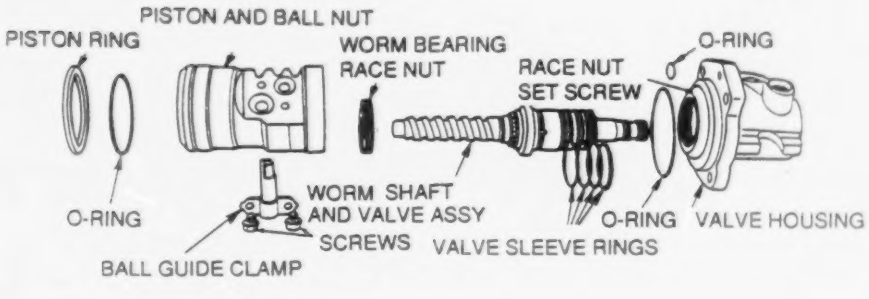
5. Described below is the path which fluid takes through a common rotary valve when the steering wheel is turned either right or left or positioned straight ahead.

a. When the steering is positioned straight ahead, fluid flows from the pump, into the gear inlet port, through the control valve, and back to the pump. No fluid flows to either side of the rack piston, although each side is full of fluid and pressure on both sides of the piston is equal.

b. When the steering wheel is turned right, the torsion bar twists and opens the valve's right turn passage. The left turn passage is closed off to pressure and opened to return oil flow. The piston nut's right turn side is, therefore, pressurized and the piston nut is forced upward. As the nut moves up, fluid is forced out of the left turn side and back to the pump reservoir through the return port.

c. When the steering wheel is turned right, the torsion bar twists and opens the valve's left turn passage. The right turn passage is closed off to pressure and opened to return fluid flow. The piston nut's left turn side is, therefore, pressurized and thus forces the piston nut downward. As the nut moves down, fluid is forced out of the right turn side and back to the pump reservoir through the return port.

6. In a variation of the rotary valve design, the spool valve is an integral part of the input shaft. The torsion bar connects the stub shaft to the worm. The worm and the valve bode rotate together. Operation of this design is similar to the design of rotary valve previously discussed.



V. Integral spool valve and pivot lever power steering system

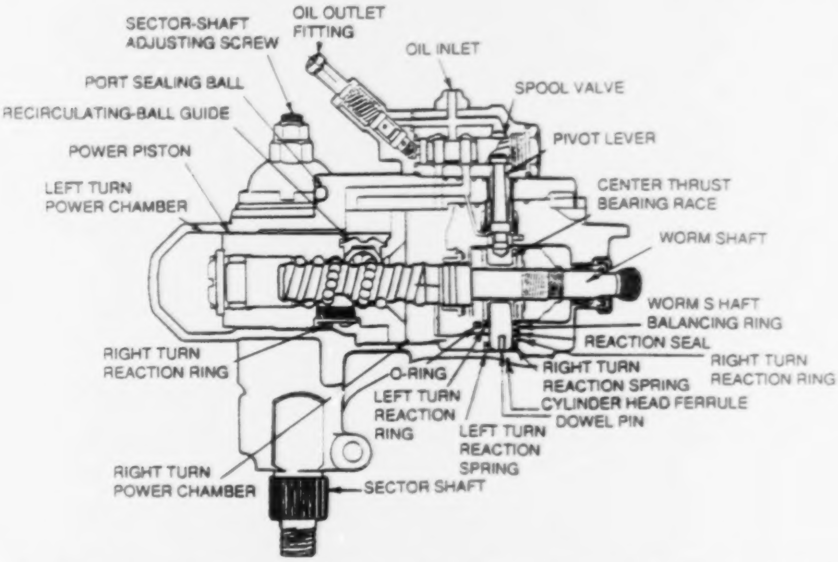
A. The power piston and worm assembly is a recirculating ball type. The piston is integral with the power piston and is double acting. In this design, however, the ball guides are in the form of a plug that screws into the power piston. The worm shaft is supported on the upper end by a bearing installed in the housing head. Two thrust bearings control end thrust.

B. The gear housing encloses the piston nut, worm shaft, and valve assembly along with the sector shaft. The steering control valve is in a separate housing, which is attached to the main gear housing. The operating control for the steering valve, however, is contained in the main housing. This arrangement will be explained later in this lesson.

1. An oil seal is placed at the upper end of the worm shaft in a housing head. The housing head is inserted into the main gear housing. The connection between the housing head and the main housing is sealed by an o-ring. A spanner nut holds the housing head in place.

2. The sector shaft is either supported in the gear housing by a needle bearing or directly mounted on bronze bushings. An oil seal retains the fluid at the sector shaft opening. An opening in the gear housing allows for sector removal. The opening has a cover that is sealed by an o-ring held in place by a spanner nut. The cover also contains the sector adjusting screw.

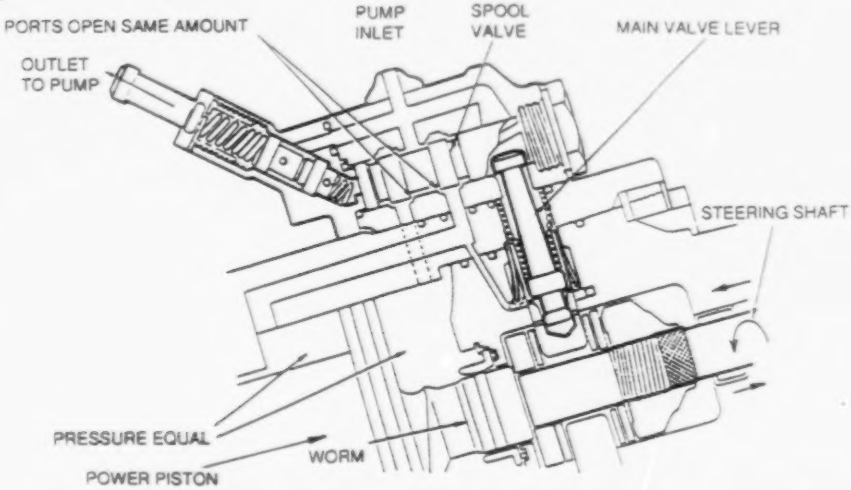
3. The gear housing has a machined bore in which the power piston travels.


SECTOR-SHAFT ADJUSTING SCREW
OIL OUTLET FITTING
OIL INLET
PORT SEALING BALL
SPOOL VALVE
RECIRCULATING-BALL GUIDE
PIVOT LEVER
POWER PISTON
LEFT TURN POWER CHAMBER
CENTER THRUST BEARING RACE
WORM SHAFT
WORM S HAFT BALANCING RING
REACTION SEAL
RIGHT TURN REACTION RING
RIGHT TURN REACTION RING
O-RING
RIGHT TURN REACTION SPRING
LEFT TURN REACTION RING
CYLINDER HEAD FERRULE
DOWEL PIN
LEFT TURN REACTION SPRING
RIGHT TURN POWER CHAMBER
SECTOR SHAFT

C. The sector gear is an integral part of the sector shaft. The design and operation of the sector shaft is similar to that of the sector shaft previously discussed.

D. The valve body assembly consists of two valves within a valve housing and an activating mechanism within the main gear housing.

1. The main valve (a spool valve) slides in a bore with the housing. As the valve moves, it opens or closes passages that admit pressurized fluid to one of the power piston chambers. As the valve opens a fluid passage to one power chamber, it opens another passage to allow fluid to return from the opposing chamber. In the centered position, the valve allows some fluid to both sides of the power piston.



2. The second valve is a pressure control valve, which is located in the outlet (fluid return) side of the control housing. Fluid pressure must overcome spring pressure to open this valve. A pivot lever in the main gear housing extends out of the top of the gear housing and into a groove in the main control valve spool. This lever will move the control valve.

    a. The lower end of the pivot lever fits in a special center thrust bearing race. This race contains a groove, which accepts the pivot lever.

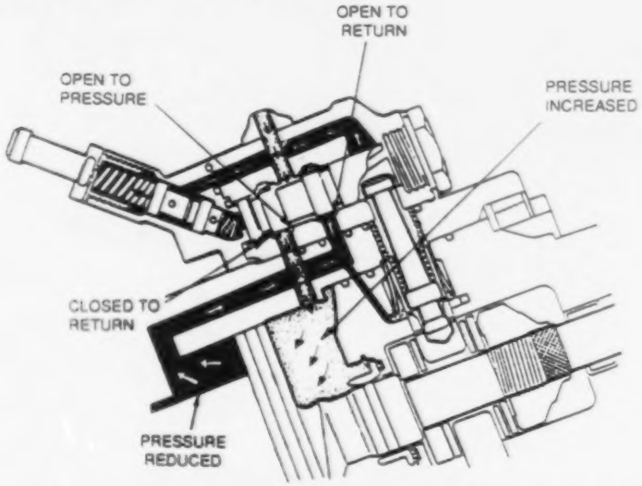
    b. When the driver turns the steering wheel, the turning force applied to the worm results in worm shaft end thrust. The end thrust is carried by two thrust bearings with the special center race between them.

    c. The end thrust causes the center race to move, thus activating the pivot lever and sliding the spool valve.

    d. The end thrust on the worm shaft changes direction as steering direction changes. The pivot lever moves the spool valve forward or backward in response to end thrust, thus opening and closing passages and controlling power assistance.

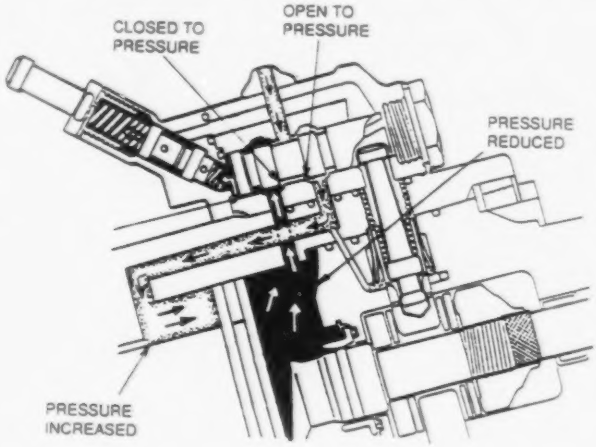
3. Two large cup-shaped springs called reaction springs are placed on either side of the center bearing race. These springs apply pressure to reaction rings and the rings against the race. When the race moves in one direction, the spring on that side is deflected. When pressure on the worm shaft is relieved, the reaction spring resumes its normal shape. The action of the spring helps to center the race and spool valve.

4. When the steering wheel is turned to the right, fluid flows in the pressure port, through the main valve, to the right turn power chamber. As the piston moves toward the front of the gear, fluid flows out of the left turn chamber, and is directed out of the return port and back to the pump. A passage through the cylinder head directs fluid to the rear reaction ring. This action applies pressure to the center race and aids the center spool valve when steering pressure is relieved. A worm balancing ring is added to the right turn reaction area to compensate for pressure imbalance in the system design. This ring adds extra surface area to the right turn reaction area to offset the imbalance.


OPEN TO RETURN
OPEN TO PRESSURE
PRESSURE INCREASED
CLOSED TO RETURN
PRESSURE REDUCED

5. When the steering wheel is turned to the left, fluid flows into the pressure port, through the main valve, and onto the left turn power chamber. As the piston moves toward the front of the gear, fluid flows out of the right turn chamber, and is directed out of the return port and back to the pump. A passage through the cylinder head directs fluid to the rear reaction ring. This action applies pressure to the center race and aids the center spool valve when steering pressure is relieved.

(NOTE: No worm balancing ring is used in the left turn reaction area.)


CLOSED TO PRESSURE
OPEN TO PRESSURE
PRESSURE REDUCED
PRESSURE INCREASED

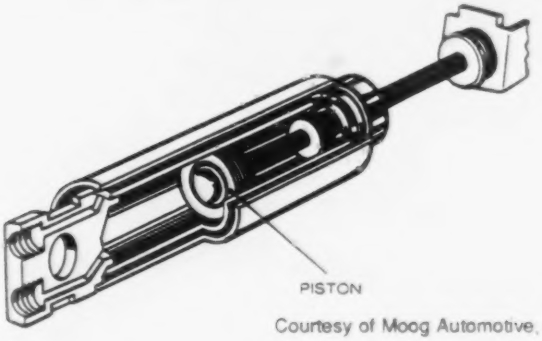
VI. Linkage type power steering

A. Major components of the linkage type power steering system include a manual steering gear, a steering control valve, a double-acting power cylinder, and the power steering pump. No hydraulic power is applied directly to the steering gear; hydraulic pressure is, however, exerted indirectly on the steering linkage via the power cylinder.

B. The steering assembly used with linkage-type power steering is similar to that used with a manual style steering system. The gear ratio is similar to that used in integral power steering systems.

C. The linkage system's power steering pump is similar to pumps used in other power steering designs.

D. The linkage system uses a double-acting power cylinder. Two fluid ports admit or discharge fluid from both sides of the cylinder. The cylinder is mounted under the vehicle from the steering linkage to the vehicle's frame. When the steering wheel is turned, the steering control valve admits fluid to one side of the power cylinder. At the same time, the control valve allows fluid to discharge from the opposing side of the cylinder and return to the pump reservoir.



Courtesy of Moog Automotive, Inc.

E. The linkage system's control valve assembly

1. The control valve housing includes a control valve, centering springs, and a ball socket assembly. Two fluid ports on the valve housing direct fluid to and from the pump. Two additional ports direct fluid in and out of the power cylinder. The valve housing is connected to the pitman arm via a tapered ball stud. The other end of the housing is threaded onto the steering linkage.

2. The control valve itself is a spool type valve, which is held in the centered position by springs. When the valve is in the centered position, fluid is allowed to move from the pump, through the spool, and to both sides of the power cylinder, thus placing equal pressure on both sides of the power piston.

3. When the steering wheel is turned hard enough, the ball socket exerts adequate pressure on the control valve to overcome spring pressure. The valve then shifts, allowing pressurized fluid to flow to one side of the cylinder while opening the other side to fluid returning from the pump. When pressure on the steering wheel is relaxed, the centering springs return the valve spool to the neutral position, and fluid pressure is again equalized on both sides of the cylinder.

MODULE: STEERING AND SUSPENSION SYSTEMS

FUNCTIONS OF CONVENTIONAL STEERING SYSTEM COMPONENTS

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. Explain how motion is transferred from the worm gear shaft to the sector gear shaft in a manual steering gear.

2. Explain how motion is transferred from the pinion shaft to the inner tie rod ends on a rack and pinion steering system.

3. Explain what occurs with regard to force systems and motion when the input piston is smaller than the output piston.

4. Explain what occurs with regard to force systems and motion when the input and output pistons are the same size.

5. Explain what occurs with regard to force systems and motion when the input piston is larger than the output piston.

6. All power steering pumps function in a very similar manner. When does the distance between the rotor and cam increase the pump?

7. All power steering pumps function in a very similar manner. When does the distance between the rotor and cam decrease the pump?

8. In the integral power steering system using a rotary valve, what components control the fluid flow through the steering gear box?

9. In the integral power steering system using a spool valve and a lever, what device moves the spool valve and lever?

10. Describe two ways how linkage type power steering differs from integral power steering.

MODULE: STEERING AND SUSPENSION SYSTEMS

FUNCTIONS OF CONVENTIONAL STEERING SYSTEM COMPONENTS

(ANSWER SHEET)

1. When the driver turns the steering wheel, the worm shaft is being turned. The ball nut rides on the bearings, which ride on the worm shaft. As the worm shaft rotates, the ball is screwed up or down the worm shaft. The ball nut is in constant mesh with the sector shaft, so when the ball nut moves, the sector shaft moves.

2. The pinion gear is connected to the steering wheel. The inner tie rods are connected to the rack. The pinion gear and the rack are in constant mesh, therefore, when the pinion gear moves, the rack and tie rod ends move.

3. The force at the output piston will increase but the area of travel will be small.

4. There will be equal force and travel by both the input and output piston.

5. There will be a decrease in force and an increase in travel at the output piston.

6. Draw in fluid from the reservoir.

7. Pressurizes the fluid and forces the fluid out of the pump.

8. The stub shaft, torsion bar, control valve.

9. The main valve lever.

10. Linkage type power steering uses a manual type steering gear, whereas the control valve and power cylinder are located outside the steering gear.

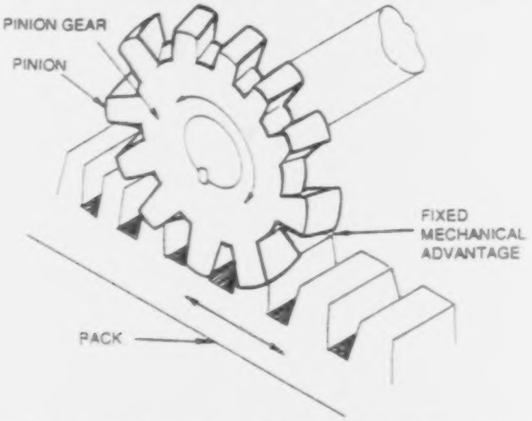
MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT I: STEERING SYSTEM DESIGN

LESSON 3: MANUAL AND POWER RACK AND PINION STEERING COMPONENTS AND OPERATION

I. Manual rack and pinion steering

A. The components of the manual rack and pinion steering system include a pinion gear, which meshes with a rack (a steel bar with teeth cut into one side). The gears are enclosed in a housing made of either aluminum or a combination of steel and aluminum. The pinion gear is attached to the steering wheel through the steering shaft. When the driver turns the steering wheel, the pinion gear rotates and moves the rack laterally. Tie rod assemblies connect the rack to the wheels; the rack movement can then steer the wheels.



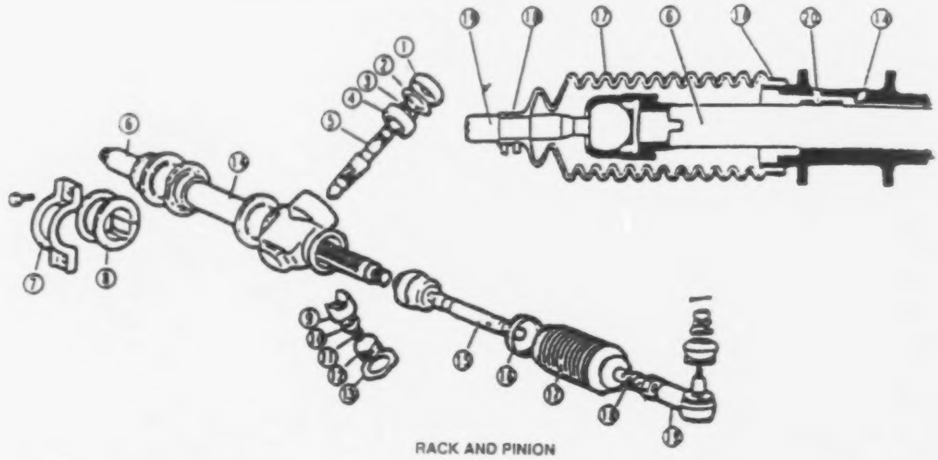
B. The rack is a round steel bar with teeth machined into one side. Nylon or metal bushings at each end of the gear housing support the rack. An adjustable, spring-loaded support bearing is sometimes used at the gear end of the rack. This bearing maintains the proper mesh between the rack and pinion gears. The inner tie rods (a ball socket assembly) attaches to each end of the rack; the tie rods are contained in housings that thread onto the ends of the rack. Bellows boots seal the inner tie rods at each end of the housing.

(NOTE: In some rack and pinion systems, the inner tie rods are connected to the center portion of the rack through an opening in the gear housing.)

C. The pinion gear can be a helical (spiral cut) or straight-cut gear. The gear is an integral part of the pinion shaft. Support for the pinion can be provided by nylon bushings and upper and lower thrust bearings (or upper and lower bearings). A preload adjuster sets the proper pinion bearing preload.

D. The gear housing (constructed of aluminum or a combination of steel and aluminum) is usually mounted to the front crossmember under the engine. To reduce noise and vibration, the housing is usually mounted in rubber bushings or grommets. Lubricant in the housing cannot be checked after housing assembly. (A seal at the pinion shaft retains the lubricant.) Rubber or plastic bellows at both ends of the housing protect the inner tie rods and retain the lubricant at the rack ends.

(NOTE: The manual rack and pinion system can be positioned in front or behind the engine. When it is positioned behind the engine, it can be located either on the crossmember or mounted on the frame rail.)



RACK AND PINION

1. OIL SEAL
2. SNAP RING
3. SNAP RING
4. BEARING
5. PINION
6. RACK
7. MOUNTING BRACKET
8. MOUNTING RUBBER
9. RACK SUPPORT YOKE
10. CUSHION RUBBER
11. YOKE SPRING
12. YOKE PLUG
13. LOCK NUT
14. GEAR BOX
15. TIE ROD
16. BELLOWS BAND
17. BELLOWS
18. CLIP
19. TIE ROD END
20. BUSHING

II. Power rack and pinion steering

A. The typical power rack and pinion steering unit is an integral system; the steering gear, power cylinder, and control valve are all contained in one unit. Exterior steel lines allow oil flow between the control valve and both sides of the power cylinder. The power steering pump is like those discussed previously in this module. Reinforced rubber hoses connect the pump to ports in the control valve area of the gear housing.

B. Rack construction

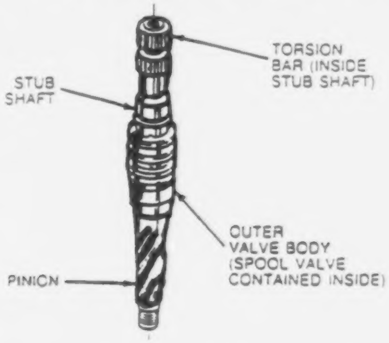
1. The rack resembles those used in manual systems. A double-acting power cylinder is installed on the rack. A teflon ring seals the piston to its bore.
2. An inner rack seal holds pressure in the left turn power piston chamber. The outer rack seal (bulkhead seal) holds steering pressure in the right turn chamber.
3. As in manual rack and pinion steering systems, an adjustable, spring-loaded rack bearing maintains the proper tension between the rack and pinion gears.
4. Inner tie rod assemblies attach directly to the rack. As in manual rack and pinion steering, the tie rods may attach to either the ends of the rack or the center of the rack.
5. Bellows type boots cover the tie rod assemblies and seal out dirt and moisture. Inner and bulkhead rack seals (not bellows boots) retain the fluid within the housing.

6. As in a manual system, the rack's teeth mesh with the pinion teeth. In a manual system, however, the pinion drives the rack right or left. In a power system, hydraulic pressure drives the rack while the pinion assembly controls rack movement.

C. In the power system, the pinion shaft and control valve assembly work in much the same way as the rotary valve assembly in an integral recirculating ball power steering system. The pinion shaft and control valve assembly consist of a stub shaft, a valve spool within the valve body, a torsion bar, and a pinion shaft with a gear.

1. When pressure is applied to the steering wheel, the torsion bar deflects. This deflection changes the relationship between the valve body and valve spool, allowing fluid to flow from the pump to the power cylinder chambers and back.

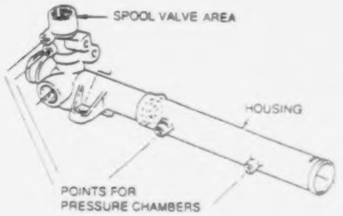
2. When turning pressure on the steering wheel is relaxed, the torsion bar returns the control valve to its neutral position, equalizing pressure on both sides of the power cylinder.


TORSION BAR (INSIDE STUB SHAFT)
STUB SHAFT
OUTER VALVE BODY (SPOOL VALVE CONTAINED INSIDE)
PINION

D. Gear housing of the power rack and pinion steering system

1. The gear housing is usually constructed of die-cast aluminum. Both the rack piston and the rotary valve travel in machined bores within the housing. Some housings have a steel insert in which the rack piston travels.

2. Exterior steel lines route fluid to and from the rack pressure chambers. These lines run from ports in the control valve portion of the housing to ports on both sides of the power piston. Two additional housing ports route fluid via hoses to and from the pump.



3. A balancing tube connects both tie rod bellows, balancing air pressure between them. When one bellows is compressed during a turn, the air trapped inside is moved through the balance tube to the opposite bellows. This is important on power gear assemblies since the inner and outer rack seals in the housing prevent any air flow inside the housing.

MODULE: STEERING AND SUSPENSION SYSTEMS

RACK AND PINION COMPONENTS

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. Describe the rack in a power rack and pinion steering system.

2. List five components of the power rack and pinion shaft and control valve assembly.

3. What do bellows boots seal at each end of the rack?

4. Describe the function of the balancing tube between the two bellows boots.

MODULE: STEERING AND SUSPENSION SYSTEMS

RACK AND PINION COMPONENTS

(ANSWER SHEET)

1. The rack is a round steel bar with teeth machined into one side.
2. Stub shaft, torsion bar, valve body, pinion shaft, and valve spool.
3. Bellows type boots seal the inner tie rods at each end of the rack.
4. When one bellows is compressed during a turn, the air trapped inside is moved through the balance tube to the opposite bellows.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT I: STEERING SYSTEM DESIGN

UNIT I TEST

SECTION A. Match the terms below with their appropriate definitions.

____ 1. The connecting link between the steering gear and the center link.

____ 2. An assembly that contains the steering shaft.

____ 3. The inner portion of the spindle.

____ 4. Component that reduces steering shimmy in some vehicles.

____ 5. Term used to describe the tie rod ends and the adjuster sleeve when they are connected.

____ 6. An arm hinged in the middle with a bushing arrangement.

____ 7. A steering gear where a pinion runs in a long bar with gear teeth machined into it.

____ 8. An internally threaded split tube used to connect the tie rod ends.

____ 9. A moveable joint that tilts and rotates.

a. Ball socket
b. Center link
c. Idler arm
d. Pitman arm
e. Rack and pinion
ab. Steering column
ac. Steering dampener
ad. Steering knuckle
ae. Tie rod assembly
bc. Tie rod adjuster sleeve

SECTION B. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 10. Twin I beam suspension systems use the center point steering system design.

____ 11. Manual steering gears generally have two sets of steel balls that ride in return guides.

____ 12. A conventional tie rod end consists of a tapered ball stud that is inserted in a steel or aluminum bearing socket.

____ 13. Tie rod sleeves are threaded with right-handed threads only.

____ 14. An idler arm is bolted securely to the steering gear.

____ 15. Steering dampeners are available and can sometimes be added to a vehicle after manufacture.

____ 16. Parallelogram steering linkage consists of one long and one short tie rod assembly with a pitman arm.

____ 17. The typical steering gear is known as the recirculating ball nut.

____ 18. Most manual steering gear boxes do not need seals.

____ 19. Rack and pinion systems allow for lower vehicle weight.

____ 20. On power rack and pinion systems, the rack is sealed by aluminum rings.

____ 21. On power rack and pinion systems, a balance tube maintains the proper fluid pressure between the sides of the hydraulic cylinder.

____ 22. The housings used on rack and pinion systems are made of cast iron.

____ 23. In rack and pinion steering systems, the rack is made of spring steel.

____ 24. Power rack and pinion steering systems use an external double-acting hydraulic cylinder.

____ 25. The power steering pump pressurizes and circulates power steering fluid.

__ 26. Power steering systems prevent the driver from getting "a feel" for the road.

____ 27. A pinion is a hydraulic device.

____ 28. In vehicles with power steering systems, the steering gear is located out of the engine compartment.

____ 29. Power steering hoses are usually made of non-reinforced rubber tubing.

____ 30. Pascal's Law deals with the characteristics of fluid.

____ 31. Power steering pumps are able to produce hydraulic pressures of over 2,000 psi.

SECTION C. Select the best answer from the five choices listed.

____ 32. Gear lash between the sector gear and rack can be adjusted by

a. moving the rack in the housing.
b. moving the sector gear in the housing.
c. removing bearings from the rack.
d. loosening the idler arm.
e. doing all of the above.

____ 33. The average gear ratio for manual steering gears is

a. 8 to 1.
b. 16 to 1.
c. 24 to 1.
d. 32 to 1.
e. 40 to 1.

____ 34. In the recirculating ball nut steering gear, the balls are between the

a. sector shaft and pitman arm.
b. sector shaft and ball nut.
c. worm shaft and ball nut.
d. worm shaft and sector shaft.
e. control valve and torsion bar.

____ 35. When hydraulic pressure is lost in power steering systems,

a. all steering control is lost.
b. the car will swerve wildly.
c. the brakes will also fail.
d. the brakes will lock up.
e. none of the above will happen.

____ 36. Linkage power steering systems use

a. internal fluid control valves.
b. two single-acting hydraulic linkages.
c. a manual style steering gear box.
d. no power steering hoses.
e. none of the above.

____ 37. The three most common types of power steering pumps are

a. gear, rotor, and positive displacement.
b. vane, roller, and slipper.
c. gear, rotor, and centrifugal.
d. non-positive displacement, roller, and gear.
e. none of the above.

____ 38. When put under pressure, a liquid will

a. be compressed.
b. increase in size.
c. become more dense.
d. become less dense.
e. do none of the above.

____ 39. The power steering pump housing contains all parts of the pump except the

a. rotor.
b. cam ring.
c. fluid reservoir.
d. pressure plate.
e. flow control valve.

____ 40. In the vane power steering pump, the low pressure needed to draw the power steering fluid from the pump intake port is created by

a. an area which is expanding.
b. an area which is shrinking.
c. the flow of the return oil.
d. atmospheric pressure.
e. all of the above.

____ 41. The rotary valve on integral power steering systems

a. reduces power steering pump pressure.
b. increases power steering pump pressure.
c. admits pressurized fluid to the correct side of the ball nut.
d. prevents the power steering pump from damaging itself.
e. does none of the above.

____ 42. On power steering systems, kickback is prevented by the

a. inlet pressure port check valve.
b. output pressure port check valve.
c. pump pressure limiter valve.
d. rotary control valve.
e. return port pressure valve.

____ 43. The rotary valve assembly consists of

a. a stub shaft valve body cap and a worm shaft.
b. a torsion bar, a valve spool, a valve body, a stub shaft, a valve body, and a worm shaft cap.
c. a spool valve, a control valve, a steering link, and a steering gear.
d. an inlet port, a thrust bearing, a torsion bar, and a stub shaft bearing.
e. none of the above.

____ 44. In pivot lever spool valve power steering systems, the control valve is activated by

a. a lever.
b. the worm shaft.
c. a torsion bar.
d. a sliding spring.
e. a steel bearing.

____ 45. The rotary valve is only found in

a. manual steering gears.
b. power steering gears.
c. power rack and pinion systems.
d. linkage type power steering systems.
e. none of the above.

(NOTE: The student must obtain a minimum score of ____ on the Unit I Test in

ANSWERS TO UNIT I TEST

1. d
2. ab
3. ad
4. ac
5. ae
6. c
7. e
8. bc
9. a
10. f
11. f
12. f
13. f
14. f
15. t
16. f
17. t
18. f
19. t
20. f
21. f
22. f
23. f
24. f
25. t
26. f
27. f
28. f
29. f
30. t
31. f
32. b
33. c
34. c
35. e
36. c
37. e
38. e
39. c
40. a
41. c
42. a
43. b
44. b
45. e

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT II: DIAGNOSING STEERING SYSTEM PROBLEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose steering systems and determine needed repairs. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with steering system diagnosis (Competency R1, Unit II Test).

II. Identify the procedures for checking and adjusting manual steering fluid levels (Competency R1, Unit II Test).

III. Identify characteristics of lubricant in manual rack and pinion steering gears (Competency R1, Unit II Test).

IV. Identify procedures for inspecting the condition and level of fluid in conventional power steering and power rack and pinion steering systems (Competency R1, Unit II Test).

V. Identify procedures for bleeding a power steering system (Competency R1, Unit II Test).

VI. Demonstrate the ability to:

a. Inspect and adjust manual steering gear lubricant levels (Competency R1, JS1-L1-UII).

b. Inspect and adjust power steering fluid levels (Competency R1, JS2-L1-UII).

Lesson 2.

I. Identify the procedures for diagnosing leaks in power steering pumps (Competency R1, Unit II Test).

II. Identify the procedures for diagnosing leaks on a conventional power steering gear (Competency R1, Unit II Test).

III. Identify the procedures for diagnosing fluid leaks in power rack and pinion systems (Competency R1, Unit II Test).

IV. Identify the procedures for diagnosing leaks in power steering hoses (Competency R1, Unit II Test).

V. Demonstrate the ability to:

  a. Diagnose fluid leaks in the power steering system (Competency R1, JS1-L2-UII).

Lesson 3. I. Identify the procedures for general steering gear road test diagnosis (Competency R1, Unit II Test).

II. Identify the causes of and corrections for manual steering gear problems (Competency R1, Unit II Test).

III. Identify the causes of and corrections for power steering gear problems (Competency R1, Unit II Test).

IV. Identify the causes of and corrections for manual rack and pinion steering gear problems (Competency R1, Unit II Test).

V. Identify the causes of and corrections for power rack and pinion steering gear problems (Competency R1, Unit II Test).

VI. Demonstrate the ability to:

  a. Diagnose manual and power steering gear problems (Competency R1, JS1-L3-UII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D002, D003, D013, and D014.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT II: DIAGNOSING STEERING SYSTEM PROBLEMS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: MANUAL AND POWER STEERING FLUIDS

    a. Information outline

    b. Assignment sheet

      AS1-L1-UII: Procedures for Inspecting and Adjusting Lubricant Levels in Manual Steering Gears

    c. Job sheets

      JS1-L1-UII: Inspecting and Adjusting Lubricant Levels in Manual Steering Gears
      JS2-L1-UII: Inspecting and Adjusting Power Steering Fluid Level

  2. Lesson 2: DIAGNOSING POWER STEERING FLUID LEAKS

    a. Information outline

    b. Job sheet

      JS1-L2-UII: Diagnosing Leaks in the Power Steering System

  3. Lesson 3: STEERING SYSTEM DIAGNOSIS

    a. Information outline

    b. Job sheet

      JS1-L3-UII: Diagnosing Manual and Power Steering Gear Problems

E. Unit test

F. Answers to unit test

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UII in conjunction with JS1-L1-UII.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT II: DIAGNOSING STEERING SYSTEM PROBLEMS

LESSON 1: MANUAL AND POWER STEERING FLUIDS

I. Terms and definitions

   A. Gear lash--The clearance between two gears.

   B. Power steering fluid--Petroleum fluid used in power steering systems.

   C. Pull--The tendency of the vehicle to drift right or left when the steering is held straight ahead.

   D. Shimmy--The inappropriate back and forth movement of the front wheels.

   E. Steering clunk--A knocking noise produced by loose steering components.

   F. Steering play--The distance that the steering wheel can be turned before the wheels respond.

   G. Wander--The left and right movement of a vehicle. Wander occurs even though the steering wheel is held firmly in the straight ahead position.

II. Manual steering fluid levels

   A. Lubricant in the manual steering gear lubricates the internal gear assembly components. The most commonly used fluids are EP (extreme pressure) multi-purpose lubricant or multi-purpose gear oil. Unless it has been contaminated, manual steering gear lubricant does not usually need to be changed. Refer to manufacturer's recommendations before adding fluid.

   B. A fill hole in the gear housing allows for inspection and adjustment of lubricant levels. Check lubricant according to the procedure outlined below.

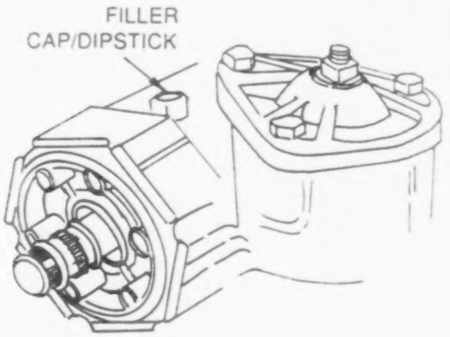
      1. Clean all dirt and grease from the gear housing fill plug area. Remove the fill hole plug.

      2. Remove the sector shaft cover bolt on the opposing end of the gear housing.

         (NOTE: If the gear housing is not equipped with a fill hole, remove upper and lower sector shaft cover bolts.)

      3. Using a clean punch or similar tool, clear away any lubricant blocking either of the two holes.

4. Slowly turn the steering to the left and right stops. Lubricant should be visible at both holes. If lubricant is not visible, add lubricant (the type recommended by the manufacturer) to the fill hole. (Add until lubricant is forced out of the bolt hole.) Reinstall and torque the bolts and/or plug to manufacturer's specifications.



III. Lubricant in manual rack and pinion steering gear will usually last the life of the vehicle; therefore, there are no provisions for inspecting the gear's lubricant level. The steering gear should, however, be routinely inspected for leaks. If a leak develops or if lubricant contamination is suspected, the steering gear must be removed, repaired, filled with the proper lubricant, and then reinstalled.

IV. Inspecting level and condition of fluid in conventional power steering and power rack and pinion steering systems

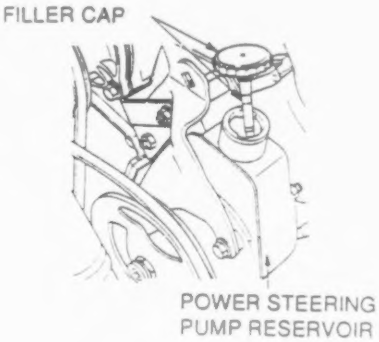
A. Power steering fluid performs the following functions: lubricates internal system components, transfers the force needed to assist steering, and cushions road shocks.

B. Most power steering systems require special fluid. Consult the appropriate service manual before adding fluid. Do not use automatic transmission fluid unless specified by the manufacturer of the vehicle.

C. Fluid inspection

1. Make sure the engine is off and the front wheels are pointed straight ahead. Remove any dirt from around the power steering dipstick.

2. Remove the dipstick and check fluid level.



3. Feel the power steering pump reservoir to see if it is warm to the touch. If the fluid temperature is not warm, the system should be filled to the full cold mark. If the fluid is warm (above 150° F), the system should be filled to the full hot mark.

4. Fill the reservoir to the correct full mark.

5. Replace the dipstick and start the engine. Allow the engine to idle as the steering wheel is slowly turned from lock to lock two or three times.

6. Shut off the engine and repeat steps 1 through 5 until the fluid level reaches the correct full mark.

   (NOTE: If the fluid is foamy, allow the vehicle to set a few minutes with the engine off. In extreme cases, the vehicle may have to set for an hour.)

   (NOTE: If the dipstick has add and full marks instead of hot and cold marks, the fluid level should be maintained between the add and full marks. If servicing an older system that does not use a dipstick, remove the reservoir cover or lid and adjust the fluid level to the reservoir's full mark.)

7. While performing the above procedure, check fluid for contamination. Metal particles in the fluid indicate a possible pump or gear failure. Milky fluid is an indication of possible moisture contamination. If contamination is discovered, the cause should be corrected and the system should be flushed according to manufacturer's instructions.

V. Sometimes air enters the power steering system during service, causing the system to function improperly and make noise. Air can be removed by bleeding the system according to the procedure outlined below. The following bleeding procedure applies to most vehicles. Check the proper service manual for the exact procedures for the vehicle to be serviced.

   A. Fill the steering reservoir according to the procedure outlined earlier in this lesson.

   B. Start the vehicle engine and run it at idle speed. Without hitting the stops hard, slowly turn the steering wheel from full left to full right several times.

   C. Stop the engine. Add fluid if required, and restart the engine.

   D. Repeat steps 2 and 3 until all the air is expelled from the system and fluid is at the hot level.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR INSPECTING AND ADJUSTING LUBRICANT LEVELS IN MANUAL STEERING GEARS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for inspecting and adjusting the steering gear lubricant level.
3. Determine and record the type of lubricant used in the steering gear to be serviced.

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND ADJUSTING LUBRICANT LEVELS IN MANUAL STEERING GEARS

Equipment:

Hand tools
Safety glasses

Procedure:

	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Using the procedure developed in AS1-L1-UII, inspect and, if necessary, adjust the lubricant level in the steering gear.	__ __ __ __

a. Be sure to clean the steering gear before removing the fill plug.

b. Record in the space below any leaks you found in the steering gear.

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competency R1. Final evaluation for R1 will be made at the end of JS1-L3-UII.)

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND ADJUSTING POWER STEERING FLUID LEVEL

Equipment:

Thermometer
Safety glasses

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Determine and record the type of power steering fluid used in the vehicle to be serviced.	__ __ __ __
(NOTE: An appropriate service manual will list the proper fluid for the vehicle.)	
3. Turn the engine off, make sure the wheels are straight, and wipe away any dirt from around the dipstick.	__ __ __ __
4. Remove the dipstick and determine the level and temperature of the fluid. Record observations.	__ __ __ __
5. Using the correct fluid, fill the system to the proper level. Replace the dipstick.	__ __ __ __
6. Start the engine and let it idle while turning the steering wheel slowly from lock to lock.	__ __ __ __
7. Repeat steps 3 through 6 to ensure that the fluid level is correct. Record observations.	__ __ __ __

(NOTE: If fluid is foamy, allow the vehicle to set a few minutes with the engine off so that the foam can dissipate. If foam is heavy, the vehicle may have to set for one hour.)

(NOTE: If the dipstick has add and full marks instead of hot and cold full marks, fluid level should be maintained between the add and full marks.)

8. Look for fluid contamination. — — — —

   a. Excessive metal particles in the fluid indicate a possible pump or gear failure.

   b. Milky fluid indicates possible moisture contamination.

   c. Record the condition of the fluid.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency R1. Final evaluation for R1 will be made at the end of JS1-L3-UII.)

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT II: DIAGNOSING STEERING SYSTEM PROBLEMS

LESSON 2: DIAGNOSING POWER STEERING FLUID LEAKS

I. Power steering pump leaks

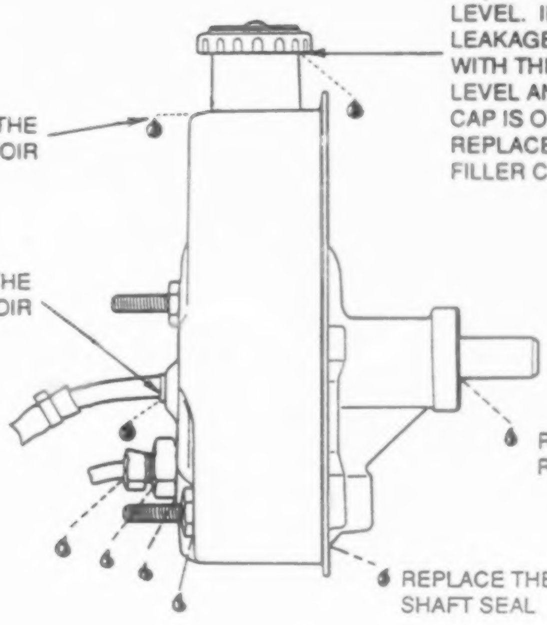
A. Following the procedure outlined below, observe the power steering pump carefully to determine the source of the leak.

1. Turn off the engine of the vehicle.
2. Thoroughly clean the pump and the connecting lines. A spray cleaner for parts can make cleaning easier.
3. Carefully examine the pump and lines for leaks.
4. Start engine and bring fluid to operating temperature.
5. Turn wheels all the way to the left and right three or four times. Do not hold the steering wheel against the stops.
6. Turn off engine and once again inspect carefully for leaks.

B. Use the following chart as a guide to leak diagnosis and correction.

SYMPTOM	CAUSE AND CORRECTION
Fluid leaking from around the dipstick	-Fluid level too high: adjust level -Dipstick or dipstick seal missing, loose, or damaged: replace dipstick
Fluid leaking at the pump body	-O-ring defective: replace o-ring -Reservoir dented or damaged: replace reservoir
Fluid leaking from reservoir body	-Broken or cracked reservoir: replace reservoir
Leakage at shaft seal	-Worn or damaged seal: replace seal -Worn shaft bushing: repair or replace pump

SYMPTOM	CAUSE AND CORRECTION
Leak at shaft and seal	-Worn or damaged pump shaft: repair or replace pump
Leak between pump and outlet fitting	-Loose outlet fitting: tighten fitting -Defective outlet fitting o-ring: replace o-ring
Leak at outlet hose fitting	-Loose hose fitting: tighten fitting -Cracked or damaged line fitting seat: replace line -Defective or missing pressure line fitting o-ring: replace o-ring
Leak at return hose connection	-Loose hose clamp: tighten clamp -Cracked or deteriorated hose: replace hose
Leak through pump housing	-Cracked or porous housing: replace pump


CHECK THE OIL LEVEL. IF THE LEAKAGE PERSISTS WITH THE CORRECT LEVEL AND THE CAP IS ON TIGHTLY, REPLACE THE FILLER CAP.
REPLACE THE RESERVOIR
REPLACE THE RESERVOIR
REPLACE THE PUMP RESERVOIR "O" RING
REPLACE THE PUMP DRIVE SHAFT SEAL

II. Diagnosing leaks on a conventional power steering gear

A. With the vehicle's engine off, inspect the steering gear carefully for leaks and attempt to find the origin of the leak.

B. Clean the steering gear. A spray cleaner for parts can make cleaning easier.

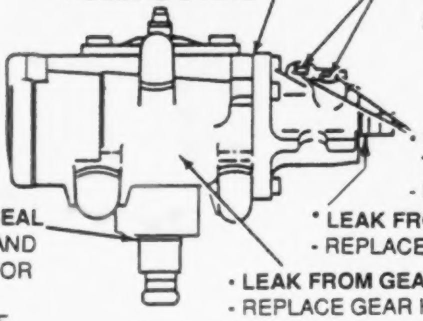
C. Start the engine and put the wheels through 3 or 4 full left and right turns.

D. Turn off engine and again inspect the pump for leaks.

E. Use the following chart as a guide to leak diagnosis and correction.

SYMPTOM	CAUSE AND CORRECTION
Fluid leakage at hose connection	-Loose fitting: tighten -Damaged fitting seat in gear housing: repair or replace steering gear -Damaged or broken hose fitting: replace hose
Fluid leakage at stub shaft seal	-Seal defective: replace seal
Leakage between stub shaft and torsion bar	-O-ring seal defective: replace seal
Leakage between housing and end plug	-O-ring seal defective: replace seal -Plug loose: repair
Leakage between main housing and control valve housing	-Bolts loose: tighten to specified torque -Defective o-ring: replace o-ring
Leakage around sector shaft ash adjuster nut	-Nut seal bad: replace nut or sealing washer

SYMPTOM	CAUSE AND CORRECTION
Fluid leakage between gear housing and sector shaft cover	-Bolts loose: torque to specification -Defective o-ring or gasket: replace
Leakage at sector shaft seal	-Worn or damaged seal: replace seal
Fluid leakage through gear housing	-Cracked or porous gear housing: Replace housing or gear assembly



- **LEAK FROM VALVE MOUNTING FACE (FORD GEAR ONLY)**
  - CHECK BOLTS FOR PROPER TORQUE. REPLACE VALVE HOUSING O-RING
- **LOOSE HOSE FITTINGS**
  - TIGHTEN HOSE FITTINGS TO SPECIFICATION
- **MISSING/DAMAGED INLET FITTING TUBE SEATS**
  - INSTALL/REPLACE TUBE SEATS
- **LEAK FROM INPUT SHAFT SEAL**
  - REPLACE INPUT SHAFT SEAL
- **LEAK FROM GEAR HOUSING.**
  - REPLACE GEAR HOUSING
- **LEAK AT SECTOR SHAFT SEAL**
  - REPLACE SECTOR SEALS AND EXAMINE SECTOR SHAFT FOR PITTING OR CORROSION. REPLACE SECTOR SHAFT IF NECESSARY

III. Diagnosing fluid leaks in power rack and pinion systems

A. With the vehicle's engine off, inspect the steering gear carefully for leaks and attempt to find the origin of the leak.

B. Clean the steering gear. A spray cleaner for parts can make cleaning easier.

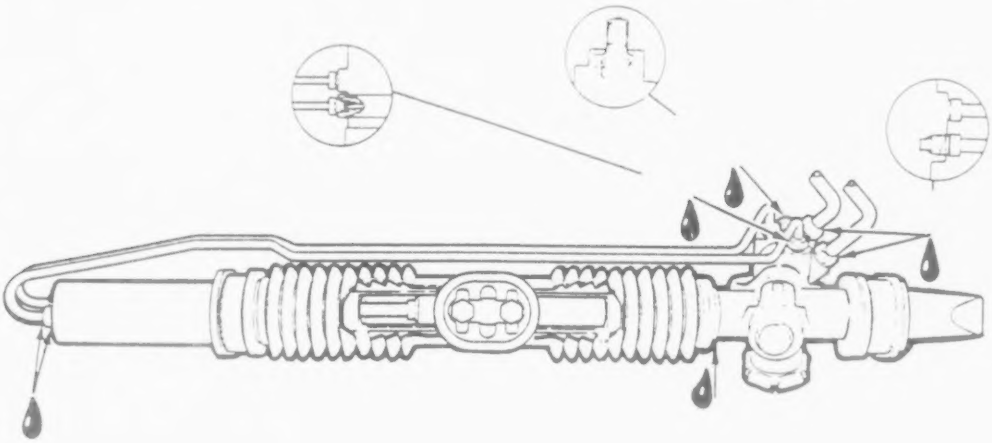
C. Start the engine and put the wheels through 3 or 4 full left and right turns.

D. Turn off engine and again inspect the pump for leaks.

E. Use the following chart as a guide to leak diagnosis and correction.

SYMPTOM	CAUSE AND CORRECTION
Leakage at pinion seal (input shaft)	-Damaged or defective seal: replace seal
Leakage between torsion bar and stub shaft	-Worn or damaged valve assembly: usually not serviceable (consult service manual and replace valve assembly)
Fluid leak at either or both bellows	-Worn or damaged rack seal or worn or damaged gear assembly: remove and disassemble the gear assembly and repair as necessary
Fluid leak at transfer line	-Loose fitting: torque to manufacturer's specification -Defective o-ring or plastic seal ring: replace as required -Broken or damaged line: replace line
Fluid leak at hose fitting	-Loose fitting: tighten to specification -Defective o-ring or plastic seal: replace as required

SYMPTOM	CAUSE AND CORRECTION
Fluid leak at hose fitting	-Damaged threads: repair or replace hose fitting or housing as required
Leakage through gear housing	-Cracked or porous housing: replace housing or steering gear



IV. Diagnosing leaks in power steering hoses

A. Visually inspect all hoses and determine the source of leakage.

B. If the leak's source cannot be determined, wipe hoses clean, start the engine, and inspect the hoses again.

C. If the leak's source still cannot be determined, have an assistant turn the steering wheel several times to the left and right to increase system pressure; doing so will make the leak easier to detect.

(NOTE: Hoses are usually not repairable and must be replaced.)

(**CAUTION:** Do not attempt to substitute a fuel hose or any other type of hose for a power steering hose. Use only hoses that have been approved for power steering systems and that have the correct pressure rating. Most other hoses cannot withstand the extreme pressure demands of a power steering system.)

MODULE: STEERING AND SUSPENSION SYSTEMS

DIAGNOSING LEAKS IN THE POWER STEERING SYSTEM

Equipment:

Trouble light
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, raise the vehicle's hood and visually inspect the steering system for leaks. ___ ___ ___ ___

   a. If the steering system is saturated with fluid, thoroughly clean all suspected components.

   b. Start the engine and make 3 or 4 full lock to lock turns.

   c. Turn the engine off and inspect systems for leaks. Record observations.

   (NOTE: In order to detect a slow leak, clean the steering system and drive the car for a distance before inspecting the system.)

3. Recommend steps to repair any leaks found in the steering system. ___ ___ ___ ___

4. Safely lift and secure the vehicle. Inspect the under-car portion of the steering system for leaks. Record observations. Recommend steps to correct any leaks. ___ ___ ___ ___

   (**CAUTION:** When lifting a vehicle, always use proper lifting equipment and safety stands.)

Average of above evaluations* ___ ___ ___ ___

(*This average is a partial evaluation for Competency R1. Final evaluation for R1 will be made at the end of JS1-L3-UII.)

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT II: DIAGNOSING STEERING SYSTEM PROBLEMS

LESSON 3: STEERING SYSTEM DIAGNOSIS

I. General steering gear road test diagnosis

(**CAUTION:** Always obtain the instructor's approval before road testing a vehicle.)

A. Find a suitable location for the road test--a road with light traffic. Perform the road test at a safe speed. Never perform a road test procedure in a manner that might cause loss of vehicle control.

B. While the car is moving, turn the steering wheel in either direction. The wheels should immediately respond. The steering wheel should have no more than two inches of play

C. Make sure the steering wheel can be turned with minimum effort. The same amount of effort should be required to turn the wheel in both directions.

(NOTE: The effort required to turn the steering wheel depends on the steering ratio, tire size, vehicle weight, etc. Take all pertinent factors into consideration when accessing the effort required to turn the wheel.)

D. The steering wheel should turn smoothly from left stop to right stop. There should be no tightness or binding.

E. When released, the steering wheel should tend to return to the straight ahead position.

F. If the vehicle hits bumps or potholes, the steering system should not make any excessive noise.

G. When the steering wheel is held firmly in the straight ahead position, the vehicle should not wander.

II. Troubleshooting charts for a manual steering gear (conventional steering system)

SYMPTOM	CAUSE AND CORRECTION
Front-end wander	-Steering linkage ball sockets worn: replace worn parts -Front end alignment incorrect: set alignment to specifications -Steering gear mounting loose: tighten attaching bolts to proper torque specifications -Excessive sector gear to ball nut lash: adjust according to manufacturer's recommendations -Worn steering gear: repair or replace steering gear
Excessive play in steering system	-Front wheel bearings loose: adjust or replace bearings -Loose steering linkage ball socket: replace socket -Excessive sector gear to ball nut lash: adjust lash or replace worn parts -Worm bearings loose or worn: adjust or replace worm bearings -Loose steering column components: repair as necessary -Worn suspension components: repair or replace as necessary
Excessive steering effort	-Low steering gear lubricant level: check and adjust level -Incorrect steering gear lubricant: drain and install proper lubricant -Steering and suspension needing lubrication: Lubricate as required -Low tire pressure: inflate to correct pressure -Steering shaft misaligned or bent: repair steering column as necessary

SYMPTOM	CAUSE AND CORRECTION
Poor returnability	-Steering gear adjusted too tight: adjust according to manufacturer's specifications -Incorrect wheel alignment: set alignment to manufacturer's specifications -Binding steering column: repair as necessary -Low or incorrect steering gear lubricant: add or change lubricant -Dry steering or suspension sockets: lubricate as required
Rattle or clanking in steering gear	-Low or incorrect steering gear lubricant: adjust lubricant level or change lubricant -Steering gear attaching bolts loose: tighten to specifications -pitman arm loose on shaft: tighten to specification -Worn steering shaft or bearings: replace as necessary -Excessive lash between sector gear and ball nut: adjust lash or replace worn parts -Loose or worn thrust bearings: adjust preload or replace as necessary (NOTE: As steering wheel is turned off the high center position, gear lash increases and a slight noise could be produced. This is normal and cannot be eliminated, as lash would then be too tight in the straight ahead position.)
Binding at a given point of turn	-Roughness in worm shaft: replace parts as required

SYMPTOM	CAUSE AND CORRECTION
Required steering effort varies from a left to a right turn	-Uneven tire pressure: adjust to specifications -Worn suspension components: replace as required -Steering gear input shaft not centered: adjust toe to center input shaft
Car pulls to one side	-Tire pressure uneven: adjust pressure to specifications -Wheel alignment incorrect: adjust alignment to specifications -Defective tire: replace tire -Suspension components worn: replace as required

III. Troubleshooting charts for power steering gear (conventional steering system)

SYMPTOM	CAUSE AND CORRECTION
Front end wander	-Steering linkage ball sockets worn: replace worn parts -Front end alignment incorrect: set all angles to specifications -Steering gear mounting loose: tighten attaching bolts to proper torque specification -Excessive lash between sector gear and piston nut: adjust according to manufacturer's recommendations -Worn steering gear: repair or replace steering gear
Excessive play in steering	-Steering gear adjustment incorrect: adjust to manufacturer's specifications -Loose or worn wheel bearings: adjust or replace bearings -Steering gear mounting loose: tighten to specification -Tie rod end loose: replace tie rod end -Worn suspension components: replace as necessary -Worn steering column components: repair as necessary
Hard steering (excessive effort required)	-Steering gear adjusted too tightly: adjust to specification -Low pressure in steering gear power cylinder due to internal leakage: disassemble and repair -Low or no pump output: repair pump or adjust fluid level -Low tire pressure: adjust to specification -Steering column binding: repair as necessary -Steering linkage or suspension in need of lubrication: lubricate as required
Poor returnability	-Steering column binding: repair as necessary -Steering gear adjusted too tightly: adjust according to manufacturer's instructions -Incorrect wheel alignment: set alignment to manufacturer's specifications

SYMPTOM	CAUSE AND CORRECTION
Gear rattle, clunk, or noise	-Dry steering linkage or suspension sockets: lubricate as required -Valve spool sticking: clean or replace valve spool as necessary -Rack piston nut to worm preload too tight: disassemble and replace balls as required
	-Excessive sector gear to piston nut lash: adjust to specifications -Gear mounting bolts loose: tighten to specified torque -Worn steering shaft or bearings: repair as necessary
	-Hissing sound: some hissing is normal when steering wheel is turned to stops or at a stand still -If hissing is excessive, check for metal contact around flexible coupling between column and gear -Squawking sound: cut or worn control valve dampener o-ring
Steering wheel jerks during turns	-Pump drive belt loose: adjust to specification
No effort required to turn wheel	-Broken torsion bar: replace control valve assembly
Vehicle pulls to one side	-Tire pressure uneven: adjust to specifications -Wheel alignment incorrect: adjust alignment to specifications -Defective tire: replace tire -Steering control valve defective or not adjusted properly: adjust or replace as required -Suspension components worn: replace as required

IV. Troubleshooting charts for a manual rack and pinion steering gear

SYMPTOM	CAUSE AND CORRECTION
Hard steering	-Rack support yoke adjusted too tightly: adjust to specification -Low tire pressure: adjust to specification -Low lubricant level or incorrect lubricant: remove steering gear and install proper fluid -Incorrect wheel alignment: set alignment to specification
Poor returnability	-Steering gear adjusted too tightly: adjust to specification -Lack of tie rod or ball joint lubrication: lubricate as required -Incorrect wheel alignment: set alignment to specifications -Binding in steering column: repair as necessary
Rattle or clunk in steering gear	-Insufficient or improper lubricant: remove rack and pinion steering gear and install correct amount and type of lubricant -Loose mounting bolts: tighten to specification
Binding at a given point in turn	-Rough or worn spot in rack: replace rack and repair as necessary
Excessive looseness in steering	-Wheel bearings loose or worn: adjust or replace bearings -Rack and pinion mounting loose: tighten to specifications -Rack and pinion incorrectly adjusted: make all adjustments according to manufacturer's specifications -Loose or worn steering column components: repair as necessary

SYMPTOM	CAUSE AND CORRECTION
Front end wander	-Steering linkage ball sockets worn: replace worn parts -Front end alignment incorrect: set alignment to specifications -Rack and pinion mounting loose: tighten attaching bolts to proper torque specification -Improper rack and pinion adjustment: adjust according to manufacturer's recommendations -Worn steering gear: repair or replace steering gear
Vehicle pulls to one side	-Tire pressure uneven: adjust to specifications -Wheel alignment incorrect: set alignment to specifications -Suspension parts worn: replace as necessary

V. Troubleshooting charts for power rack and pinion steering gear

SYMPTOM	CAUSE AND CORRECTION
Hard steering	-Internal rack leakage: repair or replace steering gear -Sticking control valve: clean or replace valve -Insufficient pump pressure: repair or replace as necessary -Low tire pressure: adjust to specifications -Steering column binding: repair as necessary -Steering gear adjusted too tightly: adjust to specification -Dry tie rod ends or ball joints: lubricate as necessary
Poor returnability	-Steering gear adjusted too tight: adjust to specification -Lack of tie rod or ball joint lubrication: lubricate as required -Incorrect wheel alignment: set alignment to specifications -Binding in steering column: repair as necessary -Sticking or blocked spool valve: replace valve assembly
Rattle or clanking noise	-Pressure hose contacting other parts of vehicle: reposition -Loose tie rod end: replace tie rod end -Loose rack mountings: tighten to specifications
Gear noise	-Hissing sound: some hissing is normal when steering wheel is turned to stops or at a stand still -Excessive hissing: replace the control valve -Groan and chatter due to air in system: bleed system

SYMPTOM	CAUSE AND CORRECTION
Excessive steering looseness	-Wheel bearings loose or worn: adjust or replace bearings -Rack and pinion mounting loose: tighten to specifications -Rack and pinion incorrectly adjusted: make all adjustments according to manufacturer's specifications -Loose or worn steering column components: repair as necessary
Front end wander	-Steering linkage ball sockets worn: replace worn parts -Front end alignment incorrect: set alignment to specifications -Steering gear mounting loose: tighten attaching bolts to proper torque specification -Improper rack and pinion adjustment: adjust according to manufacturer's recommendations -Worn steering gear: repair or replace steering gear
Vehicle pulls to one side	-Tire pressure uneven: adjust to specification -Wheel alignment incorrect: adjust to specification -Steering control valve not centered: repair or replace as required -Suspension components worn: replace as required

(NOTE: The information in all the above troubleshooting charts is general and may not apply to all steering systems. Refer to an appropriate service manual when diagnosing a specific steering system.)

MODULE: STEERING AND SUSPENSION SYSTEMS

DIAGNOSING MANUAL AND POWER STEERING GEAR PROBLEMS

Equipment:

Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Turn the steering wheel slowly from stop to stop. (If inspecting a power steering system, start the vehicle's engine and run it at an idle.) Respond to the questions below. __ __ __ __

   a. Is there binding at any point?

      Yes_____ No_____

   b. Is the same effort required to turn the steering wheel in both directions?

      Yes_____ No_____

   c. Is excessive effort required to turn the wheel?

      Yes_____ No_____

   d. Does the system make any unusual noise?

      Yes_____ No_____

   e. Does the steering wheel jerk during turns? (This question applies to power steering vehicles only.)

      Yes_____ No_____

3. Record the possible causes of any of the problems noted in item 2 above. __ __ __ __

4. After obtaining permission from the instructor, drive the car slowly and carefully. Observe if steering wheel returns properly from both left and right turns. Record observations. __ __ __ __

5. After obtaining permission from the instructor, drive the car at highway speed and respond to the following questions. — — — —

   a. Does the car pull to one side or the other?

      Yes_____ No_____

   b. Does the car wander?

      Yes_____ No_____

6. After obtaining permission from the instructor, drive the car slowly over bumps and rough pavement. Note any gear rattle or clunk. Record observations. — — — —

7. Record the possible causes of any of the problems noted in items 4 through 6 above. — — — —

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency R1. Final evaluation for R1 will be made below.)

FINAL EVALUATION INSTRUCTIONS

1. Determine the student's final evaluation for Competency R1 by averaging the evaluations of JS1-L1-UII, JS2-L1-UII, JS1-L2-UII, and JS1-L3-II. Use the spaces provided below.

	Evaluation 3	 2	 1	 N
JS1-L1-UII	—	—	—	—
JS2-L1-UII	—	—	—	—
JS1-L2-UII	—	—	—	—
JS1-L3-UII	—	—	—	—
Final evaluation for Competency R1	—	—	—	—

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT II: DIAGNOSING STEERING SYSTEM PROBLEMS

UNIT II TEST

SECTION A. Match the terms below with their appropriate definitions.

____ 1. The left and right movement of a vehicle.

____ 2. Undesirable back and forth movement of the front wheels.

____ 3. The tendency of the vehicle to drift right or left even though the steering wheel is in the straight ahead position.

____ 4. The distance that the steering wheel can be turned before the wheels will respond.

____ 5. The clearance between two gears.

a. Pull

b. Gear lash

c. Steering clunk

d. Shimmy

e. Wander

ab. Steering play

SECTION B. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 6. Front end wander can be caused by uneven tire pressure.

____ 7. Worn suspension parts can cause a vehicle to pull to one side.

____ 8. No effort should be needed to turn the steering wheel on vehicles with power steering.

____ 9. The terms "hard steering" and "excessive steering effort" refer to the same steering problem.

____ 10. When released, the steering wheel should tend to return to the straight ahead position.

____ 11. A fuel hose is an acceptable substitute for a power steering hose.

____ 12. If the source of a power steering hose leak is difficult to find, the technician should wipe hoses clean and run the engine to make the leak more apparent.

____ 13. Always make sure the bleeder screws are clear before bleeding the power steering unit.

____ 14. Milky power steering fluid indicates a possible pump or internal gear failure.

____ 15. When checking power steering fluid level, the technician should consider fluid temperature.

____ 16. The technician should not substitute automatic transmission fluid for power steering fluid unless specified by the manufacturer.

____ 17. Manual rack and pinion steering gears have no provision for lubricant level inspection.

____ 18. The lubricant in a manual steering gear usually does not need to be changed.

____ 19. The steering gear should be routinely inspected for leaks.

____ 20. Too much fluid in a power steering system can result in leakage around the dipstick.

____ 21. A loose power steering belt can cause the steering wheel to be "jerky" when turning.

SECTION C. Select the best answer from the five choices listed.

____ 22. The power steering system should be flushed

a. after repairs.
b. if the vehicle is over two years old.
c. if metal particles are discovered in the fluid.
d. if the system runs low on fluid.
e. at none of the above times.

____ 23. The lubricant most commonly used in manual steering boxes is

a. power steering fluid.
b. single-weight motor oil.
c. multi-viscosity motor oil.
d. multi-purpose gear oil.
e. manual steering fluid.

____ 24. The term that refers to the distance that the steering wheel can be moved before the wheels will respond is steering

a. slack.
b. tolerance.
c. looseness.
d. runout.
e. play.

____ 25. Power steering systems use special hoses because of the

a. corrosive nature of the fluid.
b. high heat generated by the system.
c. greater profit margin in special hose sales.
d. hydraulic pressures developed in the system.
e. problems associated with bleeding the system.

SECTION D: Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

____ 26. Technician I says that automatic transmission fluid can be substituted for power steering fluid in most late-model cars.

Technician II says that a proper repair manual will usually indicate the correct power steering fluid to use in a particular vehicle.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 27. Technician I says that improper wheel alignment can cause steering clunk.

Technician II says that excessive steering runout can cause steering clunk.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 28. Technician I says that tire size can affect the amount of effort required to turn the steering wheel.

Technician II says that a vehicle's body design can affect the amount of effort required to turn the steering wheel.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 29. Technician I says that lubricant should be routinely added to manual rack and pinion steering gears.

Technician II says that the lubricant level of manual rack and pinion gears may be inspected and adjusted through a fill hole in the gear housing.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 30. Technician I says that the vehicle should not be running while the power steering fluid is being checked.

Technician II says that the temperature of power steering fluid should be considered when checking the fluid level.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of ____ on the Unit II Test in order to receive an evaluation for Competency R1.)

ANSWERS TO UNIT II TEST

1.	a
2.	d
3.	e
4.	ab
5.	b
6.	f
7.	t
8.	f
9.	t
10.	t
11.	f
12.	t
13.	f
14.	f
15.	t
16.	t
17.	t
18.	t
19.	t
20.	t
21.	t
22.	c
23.	d
24.	e
25.	d
26.	b
27.	d
28.	a
29.	d
30.	c

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT III: INSPECTING AND REPLACING STEERING LINKAGE COMPONENTS

UNIT OBJECTIVE

After completing this unit, the student should be able to identify, repair, and replace worn steering linkage components. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with steering linkage replacement and repair (Competency R7, Unit III Test).

II. Identify the procedures for visually inspecting the linkage (Competency R7, Unit III Test).

III. Identify the procedures for steering linkage inspection (Competency R7, Unit III Test).

Lesson 2. I. Identify the tools and procedures for breaking tapered fits between steering linkage components (Competency R7, Unit III Test).

II. Identify the procedures for lubricating steering linkage components (Competency R7, Unit III Test).

III. Identify the procedures for removing and replacing a pitman arm (Competency R7, Unit III Test).

IV. Identify the procedures for removing and replacing an idler arm (Competency R7, Unit III Test).

V. Identify the procedures for removing and replacing tie rod ends (Competency R7, Unit III Test).

VI. Identify the procedures for removing and replacing a center link (Competency R7, Unit III Test).

VII. Identify the procedures for replacing a steering dampener (Competency R7, Unit III Test).

VIII. Identify the procedures for replacing a linkage-type power steering control valve (Competency R7, Unit III Test).

IX. Identify the procedures for removing and replacing a linkage power cylinder (Competency R7, Unit III Test).

X. Demonstrate the ability to:

   a. Inspect and replace a pitman arm (Competency R7, JS1-L2-UIII).

   b. Inspect and replace a center link (Competency R7, JS2-L2-UIII).

   c. Inspect and replace tie rods (Competency R7, JS3-L2-UIII).

   d. Inspect and replace an idler arm (Competency R7, JS4-L2-UIII).

   e. Inspect and replace a steering dampener (Competency R7, JS5-L2-UIII).

   f. Inspect and replace a power steering control valve on linkage-type power steering systems (Competency R7, JS6-L2-UIII).

   g. Inspect and replace a power cylinder on a linkage-type power steering system (Competency R7, JS7-L2-UIII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D022-D028.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT III: INSPECTING AND REPLACING STEERING LINKAGE COMPONENTS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

    1. Lesson 1: PROCEDURES FOR INSPECTING LINKAGES

        a. Information outline

    2. Lesson 2: PROCEDURES FOR REPLACING LINKAGES

        a. Information outline

        b. Assignment sheets

            AS1-L2-UIII: Procedures for Inspecting, Removing, and Replacing Idler Arms
            AS2-L2-UIII: Procedures for Removing and Replacing a Steering Control Valve on a Linkage-Type Power Steering System
            AS3-L2-UIII: Procedures for Removing and Replacing a Power Cylinder on a Linkage-Type Power Steering System

        c. Job sheets

            JS1-L2-UIII: Inspecting and Replacing a Pitman Arm
            JS2-L2-UIII: Inspecting and Replacing a Center Link
            JS3-L2-UIII: Inspecting and Replacing Tie Rods
            JS4-L2-UIII: Inspecting and Replacing an Idler Arm
            JS5-L2-UIII: Inspecting and Replacing a Steering Dampener
            JS6-L2-UIII: Inspecting and Replacing a Power Steering Control Valve on a Linkage-Type Power Steering System
            JS7-L2-UIII: Inspecting and Replacing a Power Cylinder on a Linkage-Type Power Steering System

E. Unit test

F. Answers to unit test

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Chrysler Corporation. Service Manual, Rear Wheel Drive 1985 Passenger Cars. Chrysler Corporation. 1984.

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Moog Automotive Inc. Moog Front End Service Manual, Inspection and Service Procedures. St. Louis, Missouri: Moog Automotive Inc. 1986.

Toboldt, William K. and Johnson, Larry. Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair. South Holland, Illinois: The Goodheart-Willcox Company, Inc. 1981.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L2-UIII in conjunction with JS4-L2-UIII; AS2-L2-UIII in conjunction with JS6-L2-UIII; and AS3-L2-UIII in conjunction with JS7-L2-UIII.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT III: INSPECTING AND REPLACING STEERING LINKAGE COMPONENTS

LESSON 1: PROCEDURES FOR INSPECTING LINKAGES

I. Terms and definitions

A. Castellated nut--A nut with a series of slots cut into one of its ends. A cotter pin is inserted through the slots to lock the nut in place.

B. Pickle fork--A heavy, fork-shaped steel tool used to separate a tapered ball stud from the part to which it is attached.

C. Pitman arm puller--A special screw-type puller used to separate the pitman arm from the splined sector shaft.

D. Self-locking nut--A special nut that locks in place as a result of the friction created between itself and a bolt or stud.

E. Taper breaker--A tool used to remove a tapered stud from a tapered hole. A taper breaker is sometimes referred to as a tie rod press.

F. Toe--The compared distance between the extreme edges of the tires at spindle height from the front of the tire to the back of the tire.

(NOTE: If the distance measured at the front of the tires is less than that measured at the rear of the tires, the condition is called toe in. The opposite condition is called toe out.)

II. Visually inspecting the linkage

A. safely lift and secure the vehicle. Clean excessive dirt and grease from all linkage components and inspect the linkage according to the procedure outlined below.

1. Inspect ball socket seals. Look for missing or badly deteriorated seals. Defective seals allow water and dirt to enter the socket assembly, causing premature failure.

2. If linkage is equipped with lubrication fittings or plugs, make sure that they are in place. If fittings are missing, contaminants will enter the socket.

3. Inspect all fasteners. Look for loose or missing nuts and bolts. Make sure that cotter pins are in place. Check for improper fasteners (nuts and bolts).

   (NOTE: Steering components use specially designed fasteners. Use of fasteners other than those specified by the manufacturer could cause steering failure.)

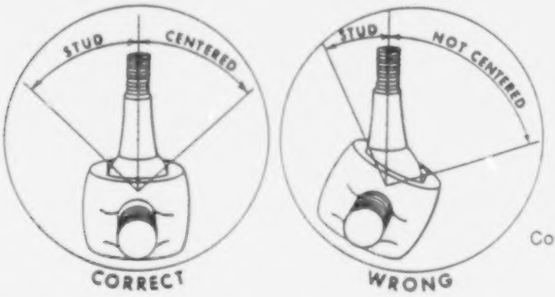
4. Make sure the linkage is not bent, cracked or broken. Also look for improper repairs of previous damage. Note any bent parts that have been straightened or any broken parts that have been welded. All damaged linkage components must be replaced; they should never be repaired.

(**CAUTION:** Never attempt to straighten or repair linkage parts with heat applications. Never weld a broken steering linkage part. Never straighten a bent steering linkage. Such procedures can weaken the linkage, causing steering failure.)

B. Procedure for inspecting tie rod assemblies

1. Perform the linkage inspection outlined under item "A" above.

2. Make sure that the sockets are centered. Ball studs need to be centered in their sockets before the sleeve clamps are tightened. If the studs are not centered, they will be locked in position and, therefore, will be unable to swing.



Courtesy of Moog Automotive, Inc

3. Check tie rod sleeves for rust or distortion. Tie rod sleeves that are badly rusted or distorted should be replaced.

   (NOTE: A special tie rod adjusting tool is sometimes used to turn the sleeve during wheel alignment. If the sleeve is badly rusted, it may distort instead of turning.)

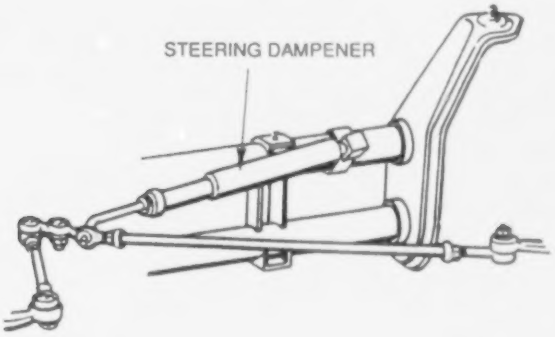
C. Inspect the idler arm for badly deteriorated rubber bushings. Also make sure the idler arm bracket is securely mounted to the frame of vehicle.

D. Inspect the steering dampener.

1. Look for fluid leakage at the piston rod. A light film or fluid on the housing around the rod is considered normal. If heavy wetness or dripping fluid is found, replace the rod.

2. Inspect the piston rod for pitting and for bends.

3. Inspect the condition of rubber grommets used to mount the rod.



E. Visually inspect the linkage-type power steering control valve for leaks. Also inspect the condition of the hose. Badly deteriorated or leaking hoses should be replaced. Details on hose inspection and replacement are presented later in this module.

F. Inspect the linkage-type power steering power cylinder.

   1. Look for fluid leakage at any point along the cylinder. A slight film of oil on the cylinder's piston rod seal is normal.

   2. Inspect the piston rod for pitting or damage. If defects are found, the cylinder should be replaced.

   3. Inspect the condition of the hoses leading to and from the cylinder.

III. Steering linkage inspection

A. Perform the visual inspection first. Use an appropriate service manual to determine the proper tolerances of a component before passing or failing it.

B. Grasp the pitman arm at the linkage end and shake vigorously. If any movement is detected, isolate the cause.

   1. If there is play in the ball socket, the pitman arm or center link may have to be replaced (depending on which part contains the socket).

   2. Movement may be the result of looseness between the tapered stud and hole. If the hole is worn, the part must be replaced.

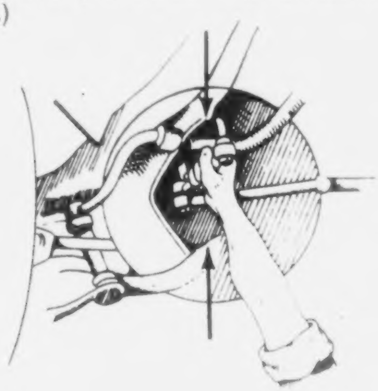
   3. If looseness is detected in the steering gear, the gear should be repaired or replaced. Steering gear repair will be covered in a later unit.

C. Idler arms that are not manufactured by General Motors can be inspected by grasping the linkage at the idler arm and applying upward and downward pressure. If the arm moves excessively, it should be replaced. Consult the appropriate service manual for specifications. General Motors recommends the following special testing procedure for their idler arms.

   1. Apply a 25 lb. upward and downward force to the idler arm.

   2. Measure idler arm movement in both directions. Total movement should not exceed 1/4 of an inch.

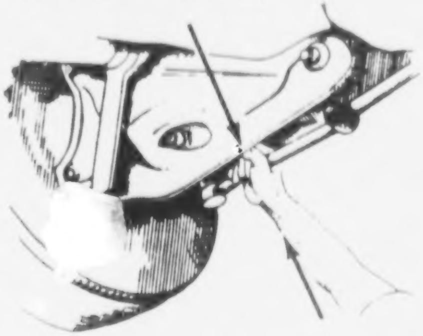
   (NOTE: Depending on the car line, the maximum movement may be as little as 1/8 of an inch.)



D. Inspect the tie rods and the center link.

1. Grasp the tie rod near the ball socket and apply vertical pressure. Excessive movement requires replacement of the loose part. (Be sure to look for movement in the tapered hole before determining if the socket is defective.) Consult the service manual for specifications and more specific procedures.

2. Twist the tie rod socket back and forth. Replace any sockets that are frozen or rough. Center any sockets that are not centered. (Inner and outer tie rod sockets that are not centered will not twist.)



E. Test for lateral looseness in linkage sockets.

(NOTE: Two technicians are required to test linkage sockets for lateral looseness. During the test, the tires must support the total vehicle weight; therefore, the vehicle can be tested either on the floor or on a drive-on hoist.)

1. While an assistant turns the steering wheel back and forth (one to two inches), observe all steering components for excessive looseness.

2. Any component found to be loose should be replaced. Consult the appropriate service manual for the particular specifications.

MODULE: STEERING AND SUSPENSION SYSTEMS

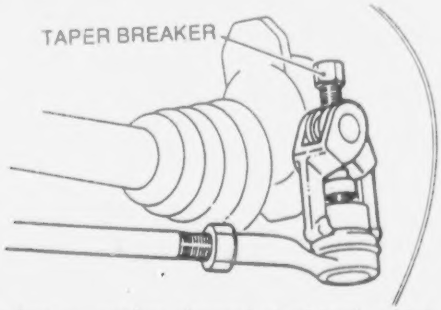
UNIT III: INSPECTING AND REPLACING STEERING LINKAGE COMPONENTS

LESSON 2: PROCEDURES FOR REPLACING LINKAGES

I. Tie rod ends, center links, pitman arms, and other steering linkage components usually use ball studs that fit tightly into tapered holes. Special tools, such as the taper breaking tool and the pickle fork, can be used to break the tapered fit between the stud and hole. Sometimes common hammers work well for this task.

(**CAUTION:** Always wear eye protection when repairing the steering system. Flying metal chips, which result from hammering, and dirt falling from undercarriage components, are all eye hazards that may be encountered during steering system repair.)

A. The taper breaking tool works like a gear puller, forcing the stud out of the hole with screw pressure. The taper breaking tool will not damage the ball stud.



B. The pickle fork is a heavy, wedge-shaped steel tool, which resembles a pickle fork. The pickle fork is forced between the ball socket and the attaching part. Some pickle forks are designed to be struck with a hammer while others are powered by a pneumatic hammer. As the fork is driven between the two parts, it forces the taper to be broken. The pickle fork disassembles the components quickly, but usually destroys the ball socket.

C. Hammers can also be used to break the tapered fit between the stud and hole. A heavy hammer is rested on one side of the attaching part at the tapered hole. Another hammer is used to strike the part directly opposite the heavy hammer, thus jarring the taper loose. This method often damages the components, and in some situations there is inadequate room to swing the hammer.

(NOTE: Never hit the end of the ball stud with a hammer; doing so will damage the ball stud's threads.)

II. Lubricating steering linkage components

A. Steering linkage components should be lubricated at regular intervals. Consult manufacturer's instructions for the proper mileage intervals at which to lubricate linkage components. If no instructions are available, lubricate every 7,500 miles. Though new components are lubricated during assembly, they should also be lubricated again after installation.

(NOTE: Always use the factory-recommended chassis lubricant--usually an EP-type lubricant--on steering linkage components.)

B. Procedure for lubricating ball sockets with a hand-operated, low-pressure grease gun

1. Wipe all grease and dirt from the grease fittings.

2. If a plug is found, remove it and install a grease fitting.

3. Snap the gun nozzle onto the fitting and apply lubricant to the socket until the grease seal starts to swell. Wipe excessive grease from the joint.

(NOTE: Forcing grease into the seal after it begins to swell may cause the seal to rupture.)

III. Removing and replacing a pitman arm

(**CAUTION:** Always wear safety glasses during steering system repairs.)

A. Procedure for removing a pitman arm

1. Safely lift and secure the vehicle.

2. Place a mark on the pitman arm and sector shaft so that the new pitman arm may be installed in the same position.

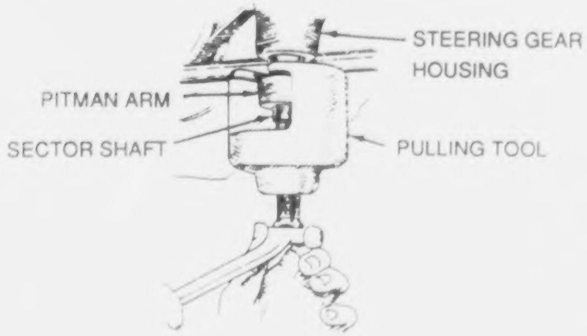
(NOTE: Most pitman arms and sector shafts have a master spline--a spline that is wider than the rest--to prevent improper installation. Adding a mark, however, provides added insurance of proper installation.)

3. Remove the cotter pin and the nut at the linkage end of the pitman arm.

4. Break the taper between the ball stud and the tapered hole.

5. Remove the nut and lock washer from the end of the sector shaft.

6. Use a pitman arm puller or suitable universal puller to remove the pitman arm from the sector shaft. The fit between the splines is very tight, sometimes making removal of the arm difficult.



B. Some pitman arms have a slit in the gear end; a clamp bolt holds the arm tight on the gear shaft.

   1. To remove this type of pitman arm, remove the clamp bolt and use a pitman arm puller to separate the arm from the shaft.

   2. To install the arm, drive a wedge in the slit, expanding the arm just enough to slide it over the splined sector shaft.

      (**CAUTION:** Never use a hammer to beat the pitman arm on or off; doing so may damage the steering gear.)

C. Procedure for installing the pitman arm

   1. Inspect the condition of the tapered hole.

      (NOTE: Depending upon its design, the pitman arm may contain a tapered hole or a ball socket. The below procedure applies, of course, to those pitman arms using a tapered hole.)

      a. Wipe any dirt or grit from the tapered hole.

      b. Visually inspect the condition of the hole. If the hole is worn, the arm must be replaced.

      c. Insert the tapered stud in the hole. Only the threaded portion of the stud should protrude. If the stud extends beyond the threads, the worn part must be replaced.

   2. Slide the pitman arm onto the sector shaft. Use the reference marks made before disassembly to position the arm.

   3. Install the washer and nut on the shaft and torque to manufacturer's specification.

   4. Insert the tapered stud in the hole and torque retaining nut to specification.

      a. Install cotter pin to lock the nut. If the openings do not line up, tighten the castellated nut to next opening and insert cotter pin.

      b. If a self-locking nut is used, the old one should be discarded and a new one of the same design installed.

IV. Removing and replacing an idler arm

(**CAUTION:** Always wear safety glasses during steering system repairs.)

A. Safely lift and secure the vehicle.

B. Remove the arm from the center link. Idler arms using a bushing arrangement require that the retaining nut be removed and that the arm be tapped or slid free from the center link. If the arm uses a tapered stud, the taper must be broken between the two parts.

C. Note the position of the support bracket; then, unbolt the support bracket from the vehicle frame and remove the arm.

D. Reverse the removal procedure to install the arm.

   1. Bolt the bracket to the frame in the same position as before. Some brackets can be reversed but wheel alignment will be changed.

   2. Tighten all fasteners to manufacturer's specified torque.

   3. Some threaded, bushing-type arms must be measured upon installation.

      a. The idler arm bracket must be threaded into the idler arm bushing until a specified measurement is met.

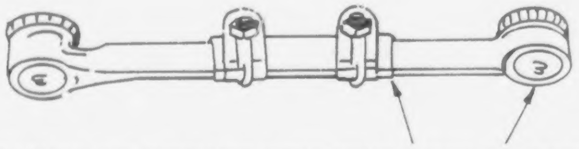
      b. Failure to make this measurement will change the toe setting on the vehicle. Specifications for this measurement can be found in an appropriate service manual.

V. Removing and replacing tie rod ends

(**CAUTION**: Always wear safety glasses during steering system repairs.)

A. Safely lift and secure the vehicle.

B. Measure the distance from the edge of the tie rod sleeve to the center of the tie rod end socket. This measurement will be used to achieve an approximate toe setting during reassembly.



MEASURE THE DISTANCE BETWEEN THE TWO ARROWS

C. Loosen the clamp on the tie rod sleeve. Penetrating oil sprayed on the sleeve and clamp bolts will make disassembly easier.

D. Remove the cotter pin and castellated nut from the end to be replaced.

E. Break the taper on the tie rod end socket.

F. Grasp the tie rod end and thread it out of the sleeve.

   1. Remove the tie rod end. If necessary, grasp the tie rod end with locking pliers to facilitate removal.

   2. Count the number of times the tie rod must be turned before it is removed from the sleeve. This number will also help position the tie rod during reassembly.

      (NOTE: The threads of the tie rod end and sleeve may be either right or left handed.)

G. Inspect the condition of the tapered hole as described previously. If worn parts are found, they must be replaced.

H. Reverse the installation procedures to install the tie rod end.

  1. Count the number of turns required to thread the tie rod end into the sleeve. Make sure that the number of times the end is turned during installation matches the number of times it was turned during removal. By matching the number of turns, the tie rod end can be positioned exactly as it was prior to disassembly.

  2. Center both the inner and outer tie rods in their sockets before tightening the clamps.

  3. Tighten all fasteners to manufacturer's specified torque.

I. Following replacement of a tie rod end, the toe should be checked and readjusted. This procedure will be covered in a later unit.

VI. Removing and replacing a center link

(**CAUTION**: Always wear safety glasses during steering system repairs.)

A. Safely lift and secure the vehicle.

B. Remove fasteners and break the taper on all connecting points.

C. Remove the center link and inspect the condition of the tapered holes as described previously.

D. Install the center link in reverse order of disassembly.

E. Torque all fasteners to manufacturer's specifications and install cotter pins on castellated nuts.

F. Check and adjust toe.

VII. Replacing a steering dampener

(**CAUTION**: Always wear safety glasses during steering system repairs.)

A. Safely lift and secure the vehicle.

B. If there is any question as to the condition of the dampener, test it according to the below procedure.

  1. Disconnect either the frame or linkage end of the dampener.

  2. Completely extend and retract the piston rod. An equal amount of resistance to piston rod movement should be felt in both directions. Movement should be smooth, with no binding or skipping.

  3. If piston rod does not have the proper resistance, replace it.

C. Disconnect both the frame and the linkage ends and remove the dampener from the vehicle. Inspect all mounting brackets and grommets. Replace any broken or deteriorated hardware.

D. Reverse the installation procedures to install the dampener.

  1. Torque all fasteners to manufacturer's specifications.

  2. Move the wheels through a full left and right turn and check for smoothness of operation.

E. Steering dampeners or their mountings vary little from manufacturer to manufacturer. The above installation description will apply to most vehicles.

VIII. Replacing a linkage-type power steering control valve

(**CAUTION**: Always wear safety glasses during steering system repairs.)

A. Procedure for removing a steering control valve

  1. Safely lift and secure the vehicle.

  2. Clean the control valve to prevent contaminants from entering the system when the control valve fluid lines are disconnected.

  3. Mark all fluid lines to ensure proper placement during reassembly.

  4. Place a drain pan under the valve assembly and disconnect the fluid lines at the control valve.

    a. Allow the fluid to drain from the lines.

    b. Observe the condition of the fluid. If it appears burnt or contaminated, the system should be flushed. The flushing procedure will be covered in a later unit.

    c. Force fluid in from the system by turning the front wheels to the left and right several times.

    (**CAUTION:** Turn wheels slowly and stay clear of the open fluid ports and lines. Fluid may be discharged under force.)

  5. Loosen the clamp bolt holding the control valve on the steering linkage.

  6. Remove the roll pin from the steering linkage through the slot in the control valve sleeve. (The roll pin can be removed with pliers.)

  7. Measure from the valve sleeve's lubrication plug to the center of the left inner tie rod end stud. Record this measurement; it will be needed during reassembly.

  8. Remove the cotter pin and castellated nut from the ball stud on the control valve.

  9. Break the taper between the pitman arm and control valve. Do not use a pickle fork; the fork's pounding force could damage the steering gear or control valve.

  10. Thread the control valve from the steering linkage. Count and record the number of turns required to remove the valve.

B. Install the control valve.

1. Thread the new control valve onto the steering linkage. The same number of turns should be used to install the new valve as was needed to remove the old one.

2. Slip the control valve ball stud into the pitman arm.

   a. As was done in the removal procedure, measure the distance from the valve sleeve lubrication plug to the center of the left inner tie rod end stud.

   b. If the distance between the lubrication plug and the left inner tie rod end stud do not match the measurement made during removal, take out the tapered stud and turn the valve in or out until the correct measurement is obtained.

   c. Once the correct measurement is obtained, install the roll pin through the slot in the control valve sleeve.

   d. The sleeve may need to be turned slightly to align with the hole in the steering linkage.

   e. The roll pin locks the control valve in place.

3. Torque the sleeve clamp bolt to manufacturer's specification.

4. Install the castellated nut on the tapered stud and torque to manufacturer's specification. Install a new cotter pin. If the nut and the hole fail to align, tighten the nut until alignment is achieved. Never loosen the nut to align the slot and hole.

5. Connect the fluid lines to the control valve. Tighten the hose fittings to the specified torque.

6. Fill the fluid reservoir with a fluid specified by the manufacturer and bleed the system.

7. Inspect the system for leaks.

8. Check and adjust toe. (This procedure will be covered in a later unit.)

IX. Removing and replacing a linkage power cylinder

(**CAUTION**: Always wear safety glasses during steering system repairs.)

A. Safely lift and secure the vehicle

B. Clean all dirt from the fluid lines going to the power cylinder.

C. Remove the fluid lines at the power cylinder and allow the fluid to drain.

D. Remove the appropriate nut, washer, and rubber insulator to disconnect the cylinder from the vehicle's frame.

E. Remove the cotter pin and castellated nut that retain the cylinder to the steering linkage.

F. Using a taper breaking tool, remove the cylinder from the steering linkage.

G. Install the cylinder in reverse order of removal.

1. Replace any hoses or rubber insulators that are deteriorated.
2. Torque all fasteners to manufacturer's specifications.
3. Fill the fluid reservoir and bleed the system.
4. Inspect for leaks. Correct any leaks found.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR INSPECTING, REMOVING, AND REPLACING IDLER ARMS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for inspecting the vehicle's idler arm. Include any specific tolerances for idler arm wear.
3. Develop a written procedure for removing the vehicle's idler arm.
4. Develop a written procedure for installing the idler arm. Be sure to include all torque specifications related to idler arm installation.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REMOVING AND REPLACING A STEERING CONTROL VALVE ON A LINKAGE-TYPE POWER STEERING SYSTEM

Instructions: **Do the following task on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for control valve removal.
3. Develop a written procedure for control valve installation. Be sure the procedure identifies the correct type of power steering fluid to be used and includes all torque specifications related to control valve replacement.
4. Develop a written procedure for control valve centering adjustment.

AS3-L2-UIII

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REMOVING AND REPLACING A POWER CYLINDER ON A LINKAGE-TYPE POWER STEERING SYSTEM

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removal of a linkage-type power cylinder.
3. Develop a written procedure for installation of a linkage-type power cylinder.
4. Determine and record the type of power steering fluid used in this system.

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING A PITMAN ARM

Equipment:

Hand tools
Ball stud taper breaker
Hoist
Pitman arm puller
Torque wrench
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Safely lift and secure the vehicle. ___ ___ ___ ___

3. Inspect the pitman arm for wear or damage. Record observations. ___ ___ ___ ___

4. Following the procedure outlined below, remove and inspect the pitman arm. ___ ___ ___ ___

   a. Place a mark on the sector shaft and pitman arm to aid in positioning the components during reassembly.

   b. Remove the cotter pin from the castellated nut that attaches the pitman arm to the steering linkage.

   c. Using a taper breaking tool, separate the pitman arm from the steering linkage.

      (**CAUTION:** If a pickle fork is used to break the taper, the ball socket may be destroyed.)

   d. Remove the nut and lock washer from the sector shaft.

   e. Using the pitman arm puller, remove the pitman arm from the steering sector shaft using the pitman arm puller.

5. Inspect the tapered hole and stud in the pitman arm and steering link. Replace any worn parts. Record observations. ___ ___ ___ ___

6. Following the procedure outlined below, install the pitman arm. ____

   a. Refer to the appropriate service manual for torque specifications. Record specifications below.

      Pitman arm to sector shaft ________

      Pitman arm to steering link ________

   b. Place the wheels in the straight-ahead position and center the steering wheel. Install the pitman arm on the sector shaft. Use the marks made before disassembly to position the guide properly.

      (NOTE: If the pitman arm has a master spline, make sure the arm aligns with it.)

   c. Install the lock washer and nut on the sector shaft and torque to specification.

   d. Attach the pitman arm to the steering linkage. Tighten the castellated nut to specified torque. Continue to tighten the nut until cotter pin can be inserted.

      (NOTE: If the opening in the castellated nut does not align with the hole in the stud, continue to tighten nut to next opening and insert cotter pin. Never loosen a nut to align openings; doing so can result in steering system failure.)

   e. If ball socket construction provides a lubrication fitting or plug, lubricate the socket with EP-type chassis lubricant.

   f. If a vehicle uses self-locking nuts instead of castellated nuts, the old nuts should be discarded and replaced with new nuts of identical design.

   g. Turn wheels through a full left and right turn to check for smooth operation. Record observations.

Average of above evaluations* ____

(This average is a partial evaluation for Competency R7. Final evaluation for R7 will be made at the end of JS2-L1-UV.)

JS2-L2-UIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING A CENTER LINK

Equipment:

Ball stud taper breaker
Hand tools
Hoist
Torque wrench
Safety glasses

Procedure:

Evaluation
1 2 3 4

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Safely lift and secure the vehicle. __ __ __ __

3. Inspect the center link for wear or damage. Record observations. __ __ __ __

4. Following the procedure outlined below, remove and inspect the center link. __ __ __ __

   a. Remove cotter pins and castellated nuts from all four connecting points.

   b. Using a taper breaker, separate the center link from the pitman arm, idler arm, and the tie rods.

      (**CAUTION:** If a pickle fork is used to break the taper, the ball socket may be destroyed.)

5. Inspect the tapered studs and mounting holes of the center link and all attaching arms. Clean excessive grease and dirt from all parts. Replace worn parts. Record observations. __ __ __ __

6. Following the procedure outlined below, install the pitman arm. — — — —

   a. Refer to the appropriate service manual for torque specifications. Record specifications below.

      Pitman arm to center link ____________

      Idler arm to center link ____________

      Tie rods to center link ____________

   b. Install the center link, tighten the attaching nuts to the specified torque and install cotter pins.

      (NOTE: If an opening in a castellated nut does not align with the hole in the stud, continue to tighten the nut to next opening and insert cotter pin. Never loosen the nut to align openings.)

   c. If a vehicle uses self-locking nuts instead of castellated nuts, the old nuts should be discarded and replaced with new ones of the same design.

   d. Lubricate all ball sockets on the center link with EP-type chassis lubricant if possible.

   e. Turn wheels through a full left and right turn to check for smooth operation. Record observations.

   f. Lower the vehicle.

   g. Check toe and adjust as necessary. See instructor for this procedure.

      Average of above evaluations* — — — —

      (*This average is a partial evaluation for Competency R7. Final evaluation for R7 will be made at the end of JS2-L1-UV.)

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING TIE RODS

Equipment:

Ball stud taper breaker
Hand tools
Hoist
Safety glasses
Torque wrench

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Safely lift and secure the vehicle. ___ ___ ___ ___

3. Inspect tie rod assembly for wear or damage. Record findings below. ___ ___ ___ ___

4. Following the procedure outlined below, remove and inspect the tie rod end. ___ ___ ___ ___

   a. Loosen the tie rod sleeve clamp bolt on the tie rod end that is to be removed.

      (NOTE: If the clamp bolt and the sleeve are rusty, spray them with penetrating oil before disassembly.)

   b. Measure the distance from the edge of the tie rod sleeve to the center of the tie rod end socket. Record this measurement below for use during reassembly.

      Measurement ______________________________

   c. Remove the cotter pin and castellated nut from the ball stud.

   d. Using a taper breaker, separate the tie rod from the center link or steering knuckle.

      (**CAUTION:** If a pickle fork is used to break the taper, the ball socket may be destroyed.)

f. Thread the tie rod end out of the adjusting sleeve. Count the number of turns required to remove the tie rod end. Record the number below.

Turns required ______________________

5. Inspect the tie rod sleeve for damage, distortion, bad threads, or severe rusting. If any of the above problems were found, the sleeve should be replaced. Observe the condition of the sleeve. Record observations. — — — —

6. Following the procedure outlined below, install the tie rod end. — — — —

a. Refer to the appropriate service manual for torque specifications. Record specifications below.

Outer tie rod to steering knuckle ________

Inner tie rod to center link ________

Adjuster sleeve clamp bolt ________

b. Thread the tie rod end into the sleeve, and count the number of turns. Stop when the tie rod end has been turned the same amount of times as recorded in step 4f above.

c. Repeat the measurement made in step 4c above. If necessary, adjust the tie rod in or out to match the previous measurement.

d. Attach the tie rod to the steering knuckle, tighten the nut to specified torque, and install the cotter pin.

e. If a vehicle uses self-locking nuts instead of castellated nuts, the old nuts should be discarded and replaced with new nuts of identical design.

f. Center both the inner and outer tie rod ends in their sockets and tighten the clamp bolts to the specified torque.

g. If the ball socket construction provides a lubrication fitting or plug, lubricate the socket with an EP-type chassis lubricant.

h. Turn the wheels through a full left and right turn to check for smooth operation.

i. Check toe and adjust as necessary. See instructor for this procedure.

Average of above evaluations* ____

(*This average is a partial evaluation for Competency R7. Final evaluation for R7 will be made at the end of JS2-L1-UV.)

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING AN IDLER ARM

Equipment:

Ball stud taper breaker
Hand tools
Hoist
Torque wrench
Safety glasses

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	___ ___ ___ ___
2. Safely lift and secure the vehicle.	___ ___ ___ ___
3. Complete AS1-L2-UIII. Using the procedure developed in item 2 of AS1-L2-UIII, inspect the idler arm for wear or damage. Record observations.	___ ___ ___ ___
4. Following the procedure developed in item 3 of AS1-L2-UIII, remove the idler arm from the vehicle. (NOTE: After removing the idler arm, inspect the stud or mounting hole in the center link. If the hole is worn, the center link should be replaced.)	___ ___ ___ ___
5. Using the procedure developed in AS1-L2-UIII, install the idler arm.	___ ___ ___ ___
Average of above evaluations*	___ ___ ___ ___

(*This average is a partial evaluation for Competency R7. Final evaluation for R7 will be made at the end of JS2-L1-UV.)

JS5-L2-UIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING A STEERING DAMPENER

Equipment:

Hand tools
Hoist
Torque wrench
Serviceable vehicle
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Safely lift and secure the vehicle. __ __ __ __

3. Inspect steering dampener for damage and leakage. Also make sure the dampener is mounted securely. Record observations. __ __ __ __

   (NOTE: A light film of fluid on the dampener housing is considered normal.)

4. Disconnect one end of the dampener. Extend and compress the dampener, and note any problems. Answer the below questions. __ __ __ __

   Was there tightness or binding during dampener travel?

   Yes______ No________

   Was there fluid leakage during dampener travel?

   Yes______ No________

   Was there skipping (lack of resistance) during dampener travel?

   Yes______ No________

   (NOTE: If "yes" was the answer to any of the above questions, replace the dampener.)

5. Following the procedure outlined below, remove and install a steering dampener. — — — —

   a. Disconnect the opposite end of the dampener.

   b. Refer to the appropriate service manual for torque specifications. Record specifications below.

      Frame end______________

      Linkage end____________

   c. Install the dampener to the vehicle's frame and to the steering linkage. Tighten fasteners to specified torque. Install new cotter pins where used.

   d. Turn the wheels through a full left and right turn. Make sure the wheels turn smoothly. Record observations.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency R7. Final evaluation for R7 will be made at the end of JS2-L1-UV.)

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING A POWER STEERING CONTROL VALVE ON A LINKAGE-TYPE POWER STEERING SYSTEM

Equipment:

Drain pan
Hand tools
Torque wrench
Safety glasses
Hoist

Procedure:

	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Safely lift and secure the vehicle.	__ __ __ __
3. Inspect the condition of the control valve. Record observations below.	__ __ __ __
4. Complete AS2-L2-UIII. Following the procedure developed in item 2 of AS2-L2-UIII, remove the control valve from the vehicle.	__ __ __ __
5. Inspect the control valve and answer the below questions.	__ __ __ __

Does the control valve show signs of damage or leakage?

Yes_____ No______

Are there tapered holes in the pitman arm?

Yes______ No______

Are the hoses leading to the control valve in bad shape?

Yes______ No______

If "yes" was the answer to any of the above questions, describe the proper repair procedures below.

6. Following the procedure developed in item 3 of AS2-L2-UIII, reinstall the control valve. — — — —

7. Following the procedure developed in item 4 of AS2-L2-UIII, adjust control valve centering. — — — —

8. Start the vehicle's engine and turn the steering wheel completely to the left and right. Note if the power steering system is functioning normally. Record observations. — — — —

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency R7. Final evaluation for R7 will be made at the end of JS2-L1-UV.)

JS7-L2-UIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING A POWER CYLINDER ON A LINKAGE-TYPE POWER STEERING SYSTEM

Equipment:

Ball stud taper breaker
Hand tools
Hoist
Torque wrench
Safety glasses

Evaluations
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Safely lift and secure the vehicle. ___ ___ ___ ___

3. Inspect the condition of the power cylinder. Record observations. ___ ___ ___ ___

4. Complete AS3-L2-UIII. Following the procedure developed in item 2 of AS3-L2-UIII, remove the power cylinder. ___ ___ ___ ___

   (NOTE: Inspect all hoses during the removal procedure. Any worn, cracked, or leaking hoses should be replaced.)

5. Inspect the tapered hole in the center link and inspect the frame mounting bracket. Record observations. ___ ___ ___ ___

6. Following the procedure developed in item 3 of AS3-L2-UIII, reinstall the power cylinder. ___ ___ ___ ___

   *Average of above evaluations ___ ___ ___ ___

   (*This average is a partial evaluation for Competency R7. Final evaluation for R7 will be made at the end of JS2-L1-UV.)

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT III: INSPECTING AND REPLACING STEERING LINKAGE COMPONENTS

UNIT III TEST

SECTION A: Select the best answer from the five choices listed.

___ 1. A nut with a series of slots cut into one end is called a

a. lug nut.
b. wing nut.
c. lock nut.
d. castellated nut.
e. brass nut.

___ 2. The compared distance between the extreme edges of the tires at spindle height from the front of the tire to the back of the tire is called

a. alignment.
b. toe.
c. toe out.
d. toe in.
e. caster.

___ 3. Tie rod sleeves that are badly rusted or distorted should be

a. replaced.
b. cleaned and sprayed with oil.
c. heated and bent.
d. left alone.
e. loosened with great care.

___ 4. Before passing a steering system component that is suspected of being defective, the technician should consult

a. the instructor or shop owner.
b. steering repair journals.
c. the proper service manual.
d. other technicians.
e. the proper government agency.

___ 5. A tool that forces a stud out of a hole with screw pressure is called a

a. stud press.
b. steering gear puller.
c. linkage remover.
d. taper spreader tool.
e. taper breaking tool.

___ 6. A pickle fork is used to

a. pull cotter pins from steering components.
b. separate steering system components.
c. set toe measurements.
d. set caster measurements.
e. test steering system components.

___ 7. Grease should be pumped into a steering socket until the

a. seal is warm.
b. grease exists the seal.
c. grease gun is empty.
d. seal swells.
e. seal contracts.

___ 8. Following replacement of a tie rod end, the technician should check and readjust

a. the ride height.
b. the steering wheel play.
c. the steering axis.
d. the toe.
e. all the above.

___ 9. If, during control valve disassembly, the power steering fluid is found to be either contaminated or burned, the system should be

a. bled.
b. blown out.
c. flushed.
d. pumped down.
e. back flushed.

___ 10. The procedure for testing the lateral looseness in linkage sockets requires

a. one person.
b. two persons.
c. three persons.
d. four persons.
e. five persons.

SECTION B: Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

___ 11. Missing or broken seals allow water and dirt to enter the socket assembly.

___ 12. When broken, steering components can be welded back together if they are not extensively rusted.

___ 13. The idler arm bracket should be loosely mounted to the vehicle's frame.

___ 14. A light film of fluid on the housing around the steering dampener piston rod is considered normal.

___ 15. Badly deteriorated or leaking power steering hoses should be repaired instead of replaced

___ 16. When removing steering components, the technician should use hammers if he or she wishes to reuse the removed component.

___ 17. Factory-recommended chassis lubricant is normally an SG-type lubricant.

___ 18. A hammer should never be used to beat the pitman arm on or off.

___ 19. Tie rod end threads are usually right handed.

___ 20. When bleeding a power steering system, the technician should first remove the proper bleeder valve.

SECTION C: **Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

___ 21. Technician I says that a lock thread nut and a castellated nut are the same thing.

Technician II says that an idler arm and a pitman arm are interchangeable.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 22. Technician I says that a pickle fork is used to remove cotter pins.

Technician II says that, during a visual inspection of steering components, it is important to look for improper repairs of previous damage.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 23. Technician I says that the ball stud of tie rod ends, center links, pitman arms, and other steering linkage components should fit tightly into tapered holes.

Technician II says that a special tool or technique is needed to break the tapered fit between a stud and its hole.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 24. Technician I says that steering components need to be lubricated every 7,500 miles if manufacturer's lubrication instructions are not available.

Technician II says that most types of heavy grease will serve as a steering system lubricant.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 25. Technician I says that the design of steering dampeners or their mountings vary little, regardless of manufacturer.

Technician II says that safety glasses do not need to be used during most steering repair procedures.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of ____ on the Unit III Test in order to receive an evaluation for Competency R7.)

ANSWERS TO UNIT III TEST

1. d
2. b
3. a
4. c
5. e
6. b
7. d
8. d
9. c
10. b
11. t
12. f
13. f
14. t
15. t
16. f
17. f
18. t
19. f
20. f
21. d
22. b
23. c
24. a
25. a

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IV: MANUAL AND POWER STEERING GEAR SERVICE

UNIT OBJECTIVE

After completing this unit, the student should be able to service and adjust non-rack and pinion manual and power steering gears. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify the procedures for removing and installing a manual steering gear (Competency R2, Part I of the Unit IV Test).

II. Identify the procedures for disassembling and inspecting a manual steering gear (Competency R2, Part I of the Unit IV Test).

III. Identify the procedures for reassembling and adjusting the steering gear (Competency R3, Part II of the Unit IV Test).

IV. Demonstrate the ability to:

- a. Remove and install a manual steering gear (Competency R2, JS1-L1-UIV).
- b. Disassemble, clean, and inspect a manual steering gear (Competency R2, JS2-L1-UIV).
- c. Reassemble and adjust a manual steering gear (Competency R3, JS3-L1-UIV).

Lesson 2. I. Identify the procedures for removing and installing a power steering gear (Competency R2, Part I Unit UIV Test).

II. Identify the procedures for disassembling and inspecting an integral power steering gear (Competency R2, Part I of the IV Test).

III. Identify the procedures for reassembling an integral power steering gear (Competency R3, Part II of the Unit IV Test).

IV. Identify the procedures for adjusting an integral power steering gear (Competency R3, Part II of the Unit IV Test).

V. Demonstrate the ability to:

- a. Remove and install an integral power steering gear (Competency R2, JS1-L2-UIV).

b. **Disassemble**, clean, and inspect an integral power steering gear (Competency R2, JS2-L2-UIV).

c. **Reassemble** and adjust an integral power steering gear (Competency R3, JS3-L2-UIV).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D005, D006, D007, and D021.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IV: MANUAL AND POWER STEERING GEAR SERVICE

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: MANUAL STEERING GEAR REPAIR

    a. Information outline

    b. Assignment sheets

        AS1-L1-UIV: Procedures for Removing and Replacing a Manual Steering Gear
        AS2-L1-UIV: Procedures for Disassembling, Cleaning, and Inspecting a Manual Steering Gear
        AS3-L1-UIV: Procedures for Reassembling and Adjusting a Manual Steering Gear

    c. Job sheets

        JS1-L1-UIV: Removing and Installing a Manual Steering Gear
        JS2-L1-UIV: Disassembling, Cleaning, and Inspecting a Manual Steering Gear
        JS3-L1-UIV: Reassembling and Adjusting a Manual Steering Gear

2. Lesson 2: INTEGRAL POWER STEERING GEAR REPAIR

    a. Information outline

    b. Assignment sheets

        AS1-L2-UIV: Procedures for Removing and Replacing an Integral Power Steering Gear
        AS2-L2-UIV: Procedures for Disassembling, Cleaning, and Inspecting an Integral Power Steering Gear
        AS3-L2-UIV: Procedures for Reassembling and Adjusting an Integral Power Steering Gear

    c. Job sheets

        JS1-L2-UIV: Removing and Installing an Integral Power Steering Gear
        JS2-L2-UIV: Disassembling, Cleaning, and Inspecting an Integral Power Steering Gear
        JS3-L2-UIV: Reassembling and Adjusting an Integral Power Steering Gear

E. Unit test

F. Answers to unit test

REFERENCES

Buick Division, General Motors Corporation. 1982 Buick Chassis Service Manual. Buick Division, General Motors Corporation. 1981.

Chrysler Corporation. Service Manual, Rear Wheel Drive 1985 Passenger Cars. Chrysler Corporation. 1984.

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Moog Automotive Inc. Moog Front End Service Manual, Inspection and Service Procedures. St. Louis, Missouri: Moog Automotive Inc. 1986.

Toboldt, William K. and Johnson, Larry. Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair. South Holland, Illinois: The Goodheart-Willcox Company, Inc. 1981.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UIV in conjunction with JS1-L1-UIV; AS2-L1-UIV in conjunction with JS2-L1-UIV; AS3-L1-UIV in conjunction with JS3-L1-UIV; AS1-L2-UIV in conjunction with JS1-L2-UIV; AS2-L2-UIV in conjunction with JS2-L2-UIV; and AS3-L2-UIV in conjunction with JS3-L2-UIV.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IV: MANUAL AND POWER STEERING GEAR SERVICE

LESSON 1: MANUAL STEERING GEAR REPAIR

I. Removing and installing a manual steering gear

  A. Procedures for removing a manual steering gear

    1. Remove the two nuts that hold the flexible coupling to the steering shaft. Mark the steering shaft and flexible coupling to aid in proper alignment during installation.

    2. Raise and safely secure the vehicle.

    3. Remove the nut that holds the pitman arm. Mark the pitman arm and sector shaft; then remove the pitman arm using a suitable puller.

    4. Remove the bolts that hold the steering gear to the vehicle frame; then, remove the steering gear from the vehicle.

    5. Inspect the vehicle frame in the area where the steering gear is mounted. Look for signs of cracking or elongated mounting holes. Correct all such problems before installing the steering gear.

  B. Reverse the above procedure to install the steering gear. Tighten all fasteners to specified torque.

II. Disassembling and inspecting a manual steering gear

  A. Procedure for disassembling the manual steering gear

    1. Thoroughly clean the exterior of the steering gear with safety solvent.

    2. Place the steering gear in a holding fixture or in a soft-jawed vise.

    3. Center the sector shaft in the center of its travel.

      a. Turn the worm shaft from one stop to the other. (Count the number of turns required to move the shaft from stop to stop.)

      b. Turn the shaft in the opposite direction half as many times as required to reach the first stop.

    4. Remove the sector shaft.

      a. Remove the sector shaft lash adjuster lock nut.

      b. Remove the sector shaft cover fasteners. Turn the lash adjuster clockwise to remove the cover. Remove and discard the cover gasket.

      c. Slip the lash adjuster screw from the sector shaft slot.

d. Remove the sector shaft from the housing by tapping on the splined end with a soft-faced mallet.

e. Using a suitable tool, pry the sector shaft seal out of the housing. Discard the seal.

5. Remove the worm shaft.

a. Loosen the worm bearing adjuster lock nut with a soft punch.

b. Remove the lock nut and the worm bearing adjuster.

c. Remove the worm shaft and ball nut assembly from the housing.

d. Remove the worm bearing in the gear housing. Also remove the bearing in the bearing adjuster.

6. Disassemble the worm shaft.

(NOTE: Some manufacturers recommend that the worm shaft not be disassembled. These manufacturers suggest that the steering gear be serviced as a complete unit.)

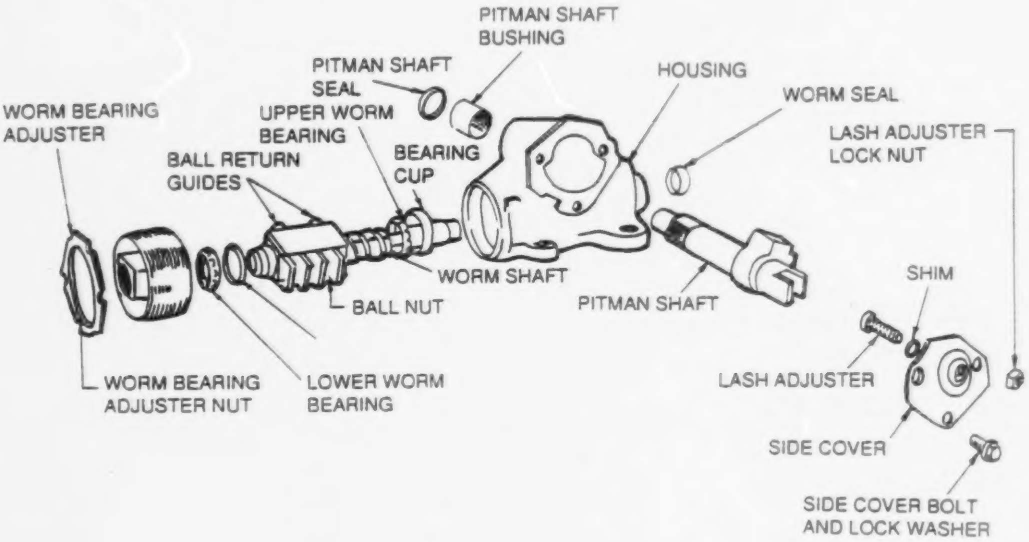
a. Unclamp and remove the return guides from the ball nut.

b. Place a clean cloth on the work bench. Turn the ball nut over and rotate the worm shaft back and forth until all the balls drop onto the cloth.

(NOTE: Carefully count the balls removed from the worm shaft. The same number of balls must be reinstalled in each circuit of the ball nut during reassembly.)

c. Remove the ball nut from the worm shaft.

d. Remove and discard the worm shaft seal.


PITMAN SHAFT BUSHING
PITMAN SHAFT SEAL
HOUSING
WORM SEAL
WORM BEARING ADJUSTER
UPPER WORM BEARING
LASH ADJUSTER LOCK NUT
BALL RETURN GUIDES
BEARING CUP
WORM SHAFT
BALL NUT
PITMAN SHAFT
SHIM
LASH ADJUSTER
WORM BEARING ADJUSTER NUT
LOWER WORM BEARING
SIDE COVER
SIDE COVER BOLT AND LOCK WASHER

B. Procedure for inspecting the steering gear

1. Thoroughly clean all parts in solvent and dry them with compressed air.

2. Inspect the worm shaft, the ball nut grooves, and the balls for wear or damage. Replace as required.

3. Inspect the ball nut and sector shaft teeth for wear or damage. Replace both if either is damaged.

4. Inspect the worm bearings for wear or damage. While turning the bearings, feel for any roughness. Any defective bearings must be replaced.

   (NOTE: Some worm adjuster bearings are not serviceable; therefore, if a nonserviceable bearing is defective, the entire adjuster must be replaced.)

5. Make sure the sector shaft fits properly between the gear housing bushings and the sector shaft cover. Replace any worn bushings.

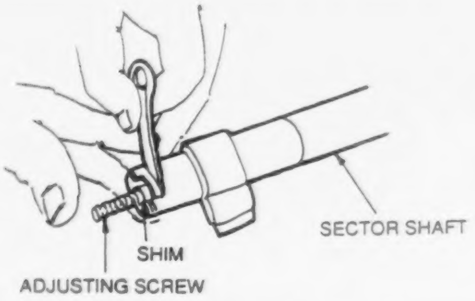
   (NOTE: If the bushing in the sector shaft cover is not serviceable, replace the cover.)

6. Inspect the surface of the sector shaft bearing for roughness or wear.

7. Make sure the lash adjuster screw fits properly in the sector shaft's slot.

   a. Make sure the screw head turns freely in the slot.

   b. Use a feeler gauge to measure the clearance between the screw head and the bottom of the slot. If the clearance fails to meet the manufacturer's specification, adjust clearance with shims.



8. Inspect the ball guides for damage. Replace if necessary.

9. Inspect the gear housing for cracks or for physical damage. Check the condition of all threaded holes.

III. Reassembling and adjusting the steering gear

A. Using the proper tools, install all bushings and bearings that were removed from the housing.

   (NOTE: Before the steering gear is assembled, lubricate all seals, bushings, and bearings with the manufacturer's recommended steering gear lubricant.)

B. Place the ball nut over the worm shaft. Position the shaft so that the deep side of the teeth are toward the shaft cover.

   1. Install an even number of balls in each ball circuit.

   2. Install the remaining balls in the ball guides. The balls should be held in place with grease.

   3. Assemble the ball guides on the ball nut.

   4 . While holding the ball nut, rotate the worm shaft several times to ensure that it is assembled properly and operates smoothly.

C. Install the worm shaft, the worm shaft bearings, and the bearing adjuster in the gear housing. Tighten the adjuster just enough to hold the assembly in place. (Final adjustments will be made later.)

D. Center the ball nut by turning the worm shaft.

E. Adjust worm shaft preload by attaching a torque wrench to the worm shaft and tightening the bearing adjuster to the specified torque. Next, tighten the adjuster lock nut.

(NOTE: The procedure for adjusting worm shaft preload will vary from vehicle to vehicle. Consult the proper service manual for the correct procedure.)

F. Install the lash adjuster screw and place the proper shim on the sector shaft. Slide the sector shaft into the gear housing. Be careful to align the center of the ball nut with the center of the sector gear.

(NOTE: Cover the splines and threads of the sector shaft with masking tape; doing so will protect the sector shaft seal during shaft installation.)

G. Place a new gasket on the sector shaft cover. Place the cover over the lash adjuster screw and turn the screw counterclockwise.

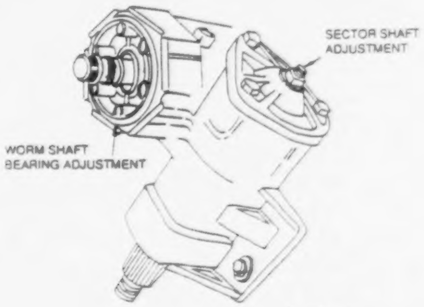
H. Tighten the sector shaft cover fasteners to manufacturer's specified torque.

I. Turn the lash adjuster screw until the teeth on the ball nut and sector shaft engage smoothly without binding. Next, install the lock nut (the nut should fit loosely).

J. Using suitable seal drivers, install sector and worm shaft seals.

K. Fill the steering gear with the manufacturer's specified lubricant.

(NOTE: Some steering gears use chassis lubricant and should be packed with grease during assembly. Refer to manufacturer's instructions.)



L. Procedure for adjusting overcenter (ball nut to sector gear clearance)

(NOTE: Overcenter can be adjusted accurately only after the worm shaft preload is adjusted.)

1. Turn the worm shaft from one stop to the other (count the number of turns required to do so.)

   (NOTE: Never allow the steering gear to bump hard against the extreme ends of its travel. A hard bump could damage the ball nut assembly.)

2. Upon reaching the stop, turn the worm shaft back half the number of turns required to meet the stop; doing so will set the steering gear on high center.

3. Adjust the lash adjuster screw until the factory-recommended turning torque on the worm shaft is achieved when passing through the high center range. (This will be a higher torque specification than the one for worm bearing preload.)

4. While holding the lash adjuster screw in position, tighten the lock nut.

5. While slowly turning the steering gear from one stop to the other, check for any roughness or binding. The steering gear should feel tighter as it passes through high center.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REMOVING AND REPLACING A MANUAL STEERING GEAR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing and installing the vehicle's manual steering gear. Be sure the procedure includes all necessary torque specifications.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR DISASSEMBLING, CLEANING, AND INSPECTING A MANUAL STEERING GEAR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for disassembling the manual steering gear.
3. Develop a written procedure for cleaning and inspecting the manual steering gear.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REASSEMBLING AND ADJUSTING A MANUAL STEERING GEAR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.

2. Develop a written procedure for reassembling the manual steering gear. Make sure to record all torque specifications related to the manual steering gear assembly. Also be sure to record the type of lubricant used in the manual steering gear.

3. Develop a written procedure for adjusting the manual steering gear. Make sure the procedure includes all necessary specifications.

JS1-L1-UIV

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING A MANUAL STEERING GEAR

Equipment:

Hand tools
Hoist
Torque wrench
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. — — — —

2. If necessary, safely lift and secure the vehicle. — — — —

3. Complete AS1-L1-UIV. Using the procedure developed in item 2 of AS1-L1-UIV, remove the steering gear from the vehicle. — — — —

4. Following the procedure outlined below, inspect the steering gear and related components. — — — —

   a. Inspect the gear mounting area of the vehicle frame for cracking or elongated holes. A damaged frame mounting area should be repaired before the gear is reinstalled. Record observations.

   b. Inspect the gear assembly for lubricant leaks or housing damage. Record observations.

   c. Inspect the flexible coupling. If the coupling is worn or damaged, it should be replaced. Record observations.

5. Following the procedure developed in item 2 of AS1-L1-UIV, install the steering gear. ____

(NOTE: Be sure to check and, if necessary, adjust the steering gear lubricant level. Refer to AS3-L1-UIV for this procedure.)

6. Check steering gear operation. Record observations. ____

Average of above evaluations* ____

(*This average is a partial evaluation for Competency R2. Final evaluation for R2 will be made at the end of JS2-L2-UIV.)

JS2-L1-UIV

MODULE: STEERING AND SUSPENSION SYSTEMS

DISASSEMBLING, CLEANING, AND INSPECTING A MANUAL STEERING GEAR

Equipment:

Hand tools
Safety glasses

Procedure: Evaluation 3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Remove the steering gear from the vehicle, if required. Refer to JS1-L1-UIV for this procedure. __ __ __ __

3. Complete AS2-L1-UIV. Following the procedure developed in item 2 of AS2-L1-UIV, disassemble the manual steering gear. __ __ __ __

   (NOTE: After removing the gear, thoroughly clean its exterior with a safety solvent.)

   (NOTE: Carefully count the number of balls removed from the ball nut. Be sure not to lose any of the balls.)

4. Following the procedure developed in item 3 of AS2-L1-UIV, clean and inspect the steering gear components. Fill out the check list below. If an item is marked NOT OK, explain the problem and suggest the appropriate steps to correct it. __ __ __ __

Worm shaft	OK____	NOT OK____
Ball nut	OK____	NOT OK____
Ball guides	OK____	NOT OK____
Worm bearings	OK____	NOT OK____
Gear housing	OK____	NOT OK____
Pitman shaft	OK____	NOT OK____
Bushings	OK____	NOT OK____
Steel balls	OK____	NOT OK____
Lash adjuster screw	OK____	NOT OK____

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competency R2. Final evaluation for R2 will be made at the end of JS2-L2-UIV.)

JS3-L1-UIV

MODULE: STEERING AND SUSPENSION SYSTEMS

REASSEMBLING AND ADJUSTING A MANUAL STEERING GEAR

Equipment:

Hand tools
Torque wrench
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS3-L1-UIV. Following the procedure developed in AS3-L1-UIV, reassemble the steering gear. During the procedure, be sure to perform the tasks listed below. ___ ___ ___ ___

   a. Replace all damaged or missing parts as directed by the instructor.

   b. Lightly coat all components with the appropriate gear lubricant during assembly. Steering gears using chassis lubricant should be packed during assembly.

   c. Tighten all fasteners to factory recommended torque.

   d. Fill the steering gear with the factory recommended lubricant.

3. Following the procedure developed in item 3 of AS3-L1-UIV, adjust the manual steering gear. ___ ___ ___ ___

4. Turn the worm shaft completely left and right several times. Note any binding or roughness. Record findings below. ___ ___ ___ ___

5. Reinstall the steering gear on the vehicle. Refer to JS1-L1-UIV for this procedure. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is a partial evaluation for Competency R3. Final evaluation for R3 will be made at the end of JS3-L2-UIV.)

MODULE: STEERING AND SUSPENSION SYSTEMS

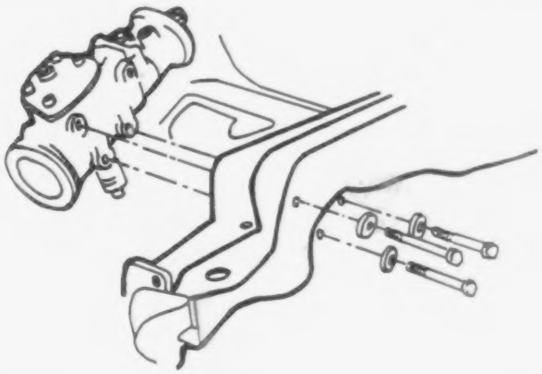
UNIT IV: MANUAL AND POWER STEERING GEAR SERVICE

LESSON 2: INTEGRAL POWER STEERING GEAR REPAIR

I. Removing and installing a power steering gear

A. Procedure for removing a power steering gear

1. Clean dirt from around hose connections. (Dirt can enter the steering gear during removal.) Place a drain pan under the gear.
2. Remove the pressure and return hoses at the gear.
3. Expel the oil from the unit by turning the steering wheel from lock to lock.
4. Disconnect the steering gear at the steering shaft coupling.
5. Safely raise and secure the vehicle.
6. Mark the pitman arm and remove it from the sector shaft.
7. Remove the bolts that hold the gear to the vehicle frame. Remove the steering gear from the vehicle.

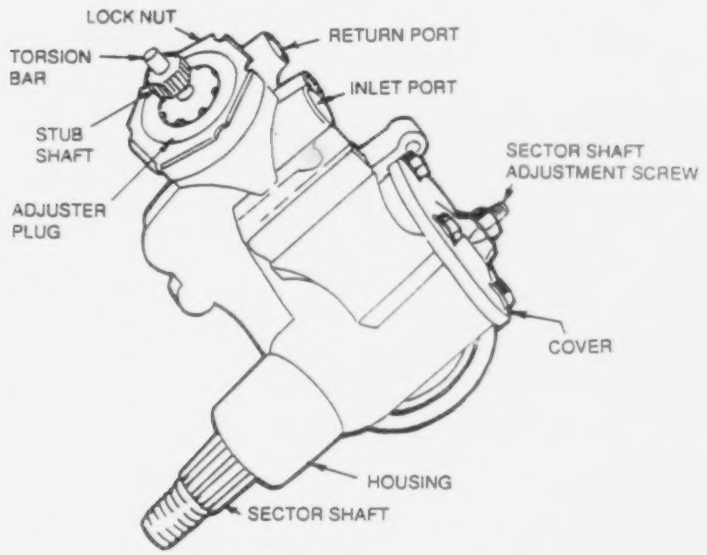


(**CAUTION:** Power steering gears are very heavy. Care should be used when removing the gear.)

B. Procedure for installing the power steering gear

1. To install the gear, simply reverse the removal procedure. Tighten all fasteners to manufacturer's specified torque.
2. Fill the pump reservoir with factory-recommended fluid and bleed the system.

3. Inspect the steering system for leaks. Repair any leaks found.



II. Disassembling and inspecting an integral power steering gear

(NOTE: Integral power steering gear designs vary from vehicle to vehicle. The following procedures are, therefore, very general. Always consult the proper service manual to obtain the correct procedure for a specific vehicle.)

(NOTE: Power steering gear repair often requires the use of special tools.)

A. Procedure for disassembling the steering gear

1. Thoroughly clean the steering gear with cleaning solvent.

2. Finish draining the steering gear by placing the hose ports over a drain pan and turning the worm shaft fully to the left and right several times.

3. Secure the steering gear in a holding fixture or mount it in a soft-jawed vise.

4. Loosen the sector shaft lash adjuster screw lock nut.

5. Remove the sector shaft cover bolts. Remove the cover and discard the o-ring.

6. Center the sector shaft in the housing. Free the sector shaft from the housing by tapping the housing's splined end with a soft-faced hammer.

7. Remove the housing end plug retaining ring. Turn the stub shaft in the left turn position until the plug is free of the housing; then, remove the plug.

8. Loosen the adjuster plug lock nut and remove the adjuster plug.

9. Remove the piston nut, worm shaft, and lower thrust bearing from the gear housing. A special tool may be necessary to hold the balls in place during disassembly.

10. Remove the stub shaft and control valve from the housing.

(NOTE: On Ford units, the control valve, worm shaft, and piston-nut can be removed together after the valve housing is removed to the gear housing retaining bolts.)

11. If the teflon rings are to be replaced, carefully cut them from the valve body and the power piston.

12. Remove and discard the adjuster plug seal and o-ring. Inspect the roller and thrust bearings in the adjuster plug. If defective, they must be replaced.

B. Procedure for disassembling the control valve assembly

1. Use great caution to ensure that the valve spool does not jam when it is removed from the valve body.

(NOTE: Due to the precise tolerances involved, at least one manufacturer discourages removal of the control unless absolutely necessary.)

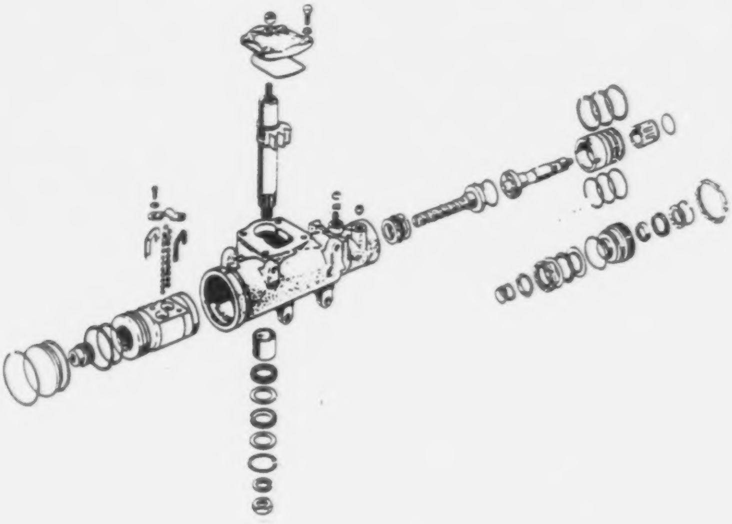
2. When a control valve is disassembled, all teflon sealing rings and rubber o-rings should be replaced with new ones.

C. Procedure for disassembling the piston nut

1. Place piston nut and worm shaft over a clean cloth. Remove the ball return guides.

2. Allow all balls to fall onto the cloth, and carefully count them.

(NOTE: On Chrysler pivot lever steering gears, the piston nut and worm are not serviceable and must be replaced as a unit.)



D. Procedure for inspecting integral power steering gear components

1. Thoroughly clean all parts in solvent and dry with compressed air.

2. Inspect the sector shaft.

    a. Inspect the shaft bearing surfaces for wear and roughness. Replace bearing if necessary.

    b. Inspect sector gear teeth for wear or roughness. Replace bearing shaft if necessary.

    c. Check cover bushing for wear. Replace cover if necessary.

3. Inspect the worm shaft and piston nut.

    a. Inspect the shaft and piston nut grooves and balls for roughness and wear. Replace these items if necessary.

    b. Inspect the power piston for wear and roughness. Replace if necessary.

    c. Inspect lower thrust bearing and races for wear or roughness. Replace these items if necessary.

    d. Inspect the outside diameter of the piston nut for wear or scoring. Replace the nut if necessary.

4. Inspect the gear housing.

    a. Inspect the piston bore. If bore is scored or worn, replace the housing.

    b. Inspect the housing for cracks and other damage. Replace the housing if necessary.

    c. Inspect the check valve in the inlet port of the housing. When pressed down and released, the valve should reseat itself against the port connector.

5. Inspect the control valve assembly.

    a. Inspect the valve assembly for leaks between the torsion bar and stub shaft. If leaks are found, replace the assembly.

    b. The spool should rotate freely in the valve body without binding. If the spool binds, replace it.

    c. Inspect the valve body and spool for wear, nicks, and burrs. If these problems are found, replace the assembly.

III. Reassembling an integral power steering gear

A. Assemble the steering gear by reversing the disassembly procedure.

B. Lubricate all seals, bushings, and bearings with power steering fluid before assembly.

C. Install teflon seals by either applying special seal installers or boiling the seals in water for five to ten minutes. The boiling water will soften and expand the seals.

D. If selective balls are used in the piston nut, make sure they are installed in the proper order.

E. Protect the new seal during installation by covering the splined end of the sector shaft with masking tape.

F. Tighten all fasteners to manufacturer's specified torque.

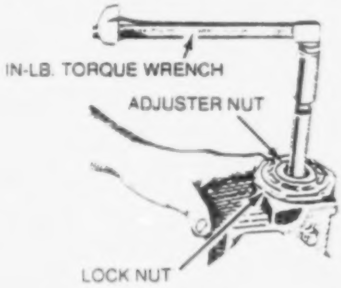
G. Use suitable drivers when installing seals and bearings.

IV. Adjusting an integral power steering gear

(NOTE: On some integral power steering gear units, the stub, or worm shaft, must be adjusted before the sector shaft can be installed.)

A. Tighten the bearing adjuster plug until the specified turning torque on the stub shaft is achieved; doing so provides the worm bearings with the proper preload.

(NOTE: On Ford steering gears, the bearing adjuster plug should be tightened before the worm assembly is installed in the gear housing.)



B. Adjust power piston nut ball preload.

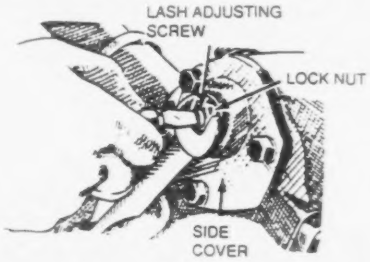
(NOTE: Power piston nut ball preload is made on some Saginaw steering gears. Preload is adjusted before the steering gear is assembled. The force needed to turn the piston nut through the high center of the worm groove is measured with a torque wrench. Adjustment is made by changing the ball size.)

C. Procedure for gear lash adjustment

1. Loosen the lash adjuster screw lock nut.

2. Using a torque wrench, turn the lash adjuster until the recommended turning torque is obtained.

3. While holding lash adjuster in position, tighten lock nut.



MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REMOVING AND REPLACING AN INTEGRAL POWER STEERING GEAR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing and installing the vehicle's power steering gear. Be sure the procedure includes all necessary torque specifications. The procedure should also indicate the type of fluid used in the steering system.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR DISASSEMBLING, CLEANING, AND INSPECTING AN INTEGRAL POWER STEERING GEAR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for disassembling the vehicle's power steering gear.
3. Develop a written procedure for cleaning and inspecting the vehicle's power steering gear.

MODULE: STEERING AND SUSPENSION SYSTEM

PROCEDURES FOR REASSEMBIING AND ADJUSTING AN INTEGRAL POWER STEERING GEAR

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.

2. Develop a written procedure for reassembling the power steering gear. Make sure the procedure includes all necessary specifications. The procedure should also indicate the type of fluid used in the steering system.

3. Develop a written procedure for adjusting the power steering gear. Make sure the procedure includes all necessary specifications.

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING AN INTEGRAL POWER STEERING GEAR

Equipment:

Hand tools
Drain pan
Hoist
Torque wrench
Safety glasses

Procedure: Evaluation 1 2 3 4

1. Wear safety glasses while doing all procedures on this job sheet. — — — —

2. If necessary, safely lift and secure the vehicle. — — — —

3. Complete AS1-L2-UIV. Following the procedure developed in item 2 of AS1-L2-UIV, remove the power steering gear. — — — —

   (NOTE: Before removal, clean all dirt from around the fluid line connections at the steering gear.)

4. Following the procedure outlined below, inspect the gear assembly. — — — —

   a. Inspect the gear assembly for fluid leakage and housing damage. Record observations.

   b. Also inspect the gear mounting area of the vehicle frame for cracking or elongated holes. Record observations.

      (NOTE: A damaged frame should be repaired before the steering gear is reinstalled. Consult the instructor for the proper procedure.)

   c. Inspect the pressure and return hoses. Record observations.

d. Inspect the flexible coupling for wear or damage. Record observations.

5. Following the procedure developed in AS1-L2-UIV, install the power steering gear. After installation, perform the tasks outlined below. — — — —

a. Make sure all defective parts are replaced.

b. Fill the steering reservoir and bleed the system.

c. Inspect for leaks and repair any leaks found. Record observations.

d. Lower the vehicle.

e. Check operation of the steering gear. Record observations.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency R2. Final evaluation for R2 will be made at the end of JS2-L2-UIV.)

MODULE: STEERING AND SUSPENSION SYSTEMS

DISASSEMBLING, CLEANING, AND INSPECTING AN INTEGRAL POWER STEERING GEAR

Equipment:

Hand tools
Drain pan
Vise or holding fixture
Various specialty tools
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Remove the steering gear from the vehicle, if required. Refer to JS1-L2-UIV for this procedure. __ __ __ __

3. Complete AS2-L2-UIV. Following the procedure developed in item 2 of AS2-L2-UIV, disassemble the power steering gear. __ __ __ __

   (NOTE: Before disassembling the power steering gear, plug fluid ports and thoroughly clean the gear's exterior with a safety solvent.)

   (NOTE: Some manufacturers do not service certain steering gear components and do not recommend steering gear disassembly. Closely follow the manufacturer's directions for the vehicle being serviced.)

4. Following the procedure outlined in item 3 of AS2-L2-UIV, clean and inspect the steering gear components. Use the below check list to determine if the components are defective. __ __ __ __

   (NOTE: Thoroughly clean all parts in clean safety solvent and blow dry.)

Control valve assembly	OK_____	NOT OK_____
Piston nut	OK_____	NOT OK_____
Worm shaft	OK_____	NOT OK_____
Stub shaft	OK_____	NOT OK_____
Control valve assembly	OK_____	NOT OK_____
Sector shaft	OK_____	NOT OK_____
Bushings	OK_____	NOT OK_____
Thrust bearings	OK_____	NOT OK_____
Gear housing	OK_____	NOT OK_____
Inlet check valve	OK_____	NOT OK_____
Steel balls	OK_____	NOT OK_____
Ball guides	OK_____	NOT OK_____

JS2-L2-UIV

If any of the above components were found to be "NOT OK," suggest appropriate repair procedures.

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competency R2. Final evaluation for R2 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency R2 by averaging the evaluations of JS1-L1-UIV, JS2-L1-UIV, JS1-L2-UIV, and JS2-L2-IV. Use the spaces provided below.

	Evaluation 3	 2	 1	 N
JS1-L1-UIV	__	__	__	__
JS2-L1-UIV	__	__	__	__
JS1-L2-UIV	__	__	__	__
JS2-L2-UIV	__	__	__	__
Final evaluation for Competency R2	__	__	__	__

JS3-L2-UIV

MODULE: STEERING AND SUSPENSION SYSTEMS

REASSEMBLING AND ADJUSTING AN INTEGRAL POWER STEERING GEAR

Equipment:

Hand tools
Torque wrench
Vise or holding fixture
Various specialty tools
Safety glasses

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Complete AS3-L2-UIV. Following the procedure developed in item 2 of AS3-L2-UIV, reassemble the steering gear. (NOTE: Be sure that all damaged or missing steering gear parts are replaced as directed by the instructor.) (NOTE: Lightly coat all components with the appropriate power steering fluid during assembly.)	__ __ __ __
3. Using the procedure developed in item 3 of AS3-L2-UIV, adjust the steering gear.	__ __ __ __
4. Turn the worm shaft completely to the left and right several times. Note any binding or roughness. Record observations.	__ __ __ __
5. Reinstall the steering gear on the vehicle if required. Refer to JS1-L2-UIV for this procedure.	__ __ __ __
Average of above evaluations*	__ __ __ __

(*This average is a partial evaluation for Competency R3. Final evaluation for R3 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. **Determine the student's final evaluation for Competency** R3 by averaging the evaluations of JS3-L1-UIV and JS3-L2-UIV. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS3-L1-UIV	__	__	__	__
JS3-L2-UIV	__	__	__	__
Final evaluation for Competency R3	__	__	__	__

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IV: MANUAL AND POWER STEERING GEAR SERVICE

UNIT IV TEST

PART I. CLEANING AND INSPECTING STEERING GEARS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. After removing a steering gear, the technician should inspect the vehicle's frame at the point where the gear box was attached.

____ 2. A steering gear should not be placed in a soft-jawed vise.

____ 3. Some manufacturers do not recommend disassembly of the worm shaft.

____ 4. All steering gear parts should be cleaned in solvent before they are inspected.

____ 5. During disassembly of the steering gear, the ball nut is usually removed before the worm shaft.

____ 6. During disassembly, the pitman arm sector shaft connection should usually be marked.

____ 7. Steering gear seals and bearings should be removed with a small hammer.

____ 8. Some manufacturers do not recommend taking apart the power steering control valve assembly.

____ 9. The piston bore should be welded if it is found to be cracked.

____ 10. During steering gear disassembly, the power steering hoses should be removed after the steering gear has been unbolted.

____ 11. During steering gear disassembly, the power steering fluid should be drained before removing the hoses.

SECTION B: **Select the best answer from the five choices listed.**

____ 12. The steering gear is connected to the steering column by the

a. pitman arm.
b. idler arm.
c. flexible coupling.
d. connecting link.
e. sector shaft.

___ 13. The sector shaft is usually removed from the steering gear box with a

a. sector shaft puller.
b. pry bar.
c. pickle fork.
d. sledge hammer.
e. soft-faced mallet.

___ 14. During steering gear disassembly, the ball nut is removed along with the

a. worm shaft.
b. sector shaft.
c. sector shaft cover.
d. lock nut bearing adjuster.
e. steering gear housing.

___ 15. In order to drain a power steering gear box, the technician should remove the

a. drain plug and turn the worm gear.
b. sector shaft seal and turn the worm gear.
c. stub shaft seal and turn the worm gear.
d. hoses and turn the worm gear.
e. reservoir gear housing.

___ 16. When removing a power steering spool valve, the technician should use extreme caution to prevent the

a. spool valve from bending.
b. spool valve from being nicked.
c. control valve body from warping.
d. teflon seals from breaking.
e. spool valve from jamming.

___ 17. Caution should be used when removing power steering gears because they

a. are slick with grease.
b. are very heavy.
c. have many sharp edges.
d. drip power steering fluid.
e. become tangled with other components.

___ 18. During steering gear disassembly, the technician should remove the sector shaft from the steering gear with a

a. soft-faced hammer.
b. special puller.
c. vise grips.
d. chisel.
e. hack saw.

____ 19. The ball nut rides on ball bearings which ride on the

a. sector shaft.
b. worm shaft.
c. stub shaft.
d. steering shaft.
e. flexible coupling shaft.

____ 20. When removing a power steering gear, the technician should clean dirt from around the gear's hose connections in order to

a. ease removal.
b. make the gear less slippery.
c. prevent contamination.
d. drain the gear.
e. reduce gear weight.

____ 21. If nicks and burs are found on the power steering control valve body and spool, the technician should

a. remove burrs from the housing and valve.
b. polish the housing and valve.
c. replace the control valve body and spool valve.
d. replace the steering gear.
e. do none of the above.

(NOTE: The student must obtain a minimum score of ____ on Part I of the Unit IV Test in order to receive an evaluation for Competency R2.)

PART II. REASSEMBLING AND ADJUSTING STEERING GEARS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 22. Steering gear components are usually replaced in the opposite order of their disassembly.

____ 23. During assembly, all fasteners should be tightened to their specified torque.

____ 24. All seals, bushings, and bearings should be lubricated before assembly of the steering gear.

____ 25. When installing the ball nut, the technician should place all the balls in one circuit.

____ 26. Worn bushing on the steering gear can often be repaired.

____ 27. When turning the steering gear through high center, the technician should detect a tighter feel.

____ 28. When the steering gear is turned through high center, gear lash usually increases.

____ 29. The power steering system can be bled by loosening a hose.

____ 30. The brake system should be bled when the power steering system is bled.

SECTION B. Select the best answer from the five choices listed.

____ 31. Overcenter adjustment (ball nut to sector gear mesh) can be made accurately only after the

a. sector shaft preload is adjusted.
b. worm shaft preload is adjusted.
c. ball nut guides are filled.
d. gear is filled with the proper lubricant.
e. worm shaft is resting against one of the stops.

____ 32. If the steering gear should bump hard against the extremes of its travel, damage may be done to the

a. sector shaft.
b. control valve.
c. stub shaft.
d. ball nut.
e. steering gear.

____ 33. One method of teflon seal installation involves

a. grinding the seals.
b. boiling the seals.
c. filing the seals.
d. sanding the seals.
e. cutting the seals.

____ 34. When putting together the ball nut assembly, the technician should rotate the assembly several times on its shaft to ensure that the

a. proper effort is required to turn the steering wheel.
b. lubricant is at its proper level.
c. assembly operates smoothly.
d. proper steering feel is obtained.
e. proper gear clearance is maintained.

____ 35. The worm shaft preload procedure involves tightening the bearing adjuster until the

a. ball nut torque is correct.
b. sector shaft ball nut clearance is correct.
c. worm shaft seals the seat.
d. worm shaft bearings seat against their races.
e. specific turning torque is obtained.

____ 36. During assembly of the steering gear, the splined end of the sector shaft is taped in order to prevent damage to the

a. brakes.
b. bushings.
c. seals.
d. spline.
e. threads.

____ 37. Turning the worm shaft from one stop to the other while counting the number of turns is the first step in

a. disassembling the steering gear.
b. bleeding the steering system.
c. centering the steering worm shaft.
d. centering the sector gear.
e. adjusting the overcenter.

____ 38. On some Saginaw steering gears, the adjustment of the rack piston nut ball preload is made by

a. adjusting the bearing preload.
b. adjusting the high center lash.
c. changing the size of the balls in the ball nut.
d. changing the number of balls in the ball nut.
e. adjusting the worm gear torque.

(NOTE: The student must obtain a minimum score of ____ on Part II of the Unit IV Test in order to receive an evaluation for Competency R3.)

ANSWERS TO UNIT IV TEST

1. t
2. f
3. t
4. t
5. f
6. t
7. f
8. t
9. f
10. f
11. f
12. c
13. e
14. a
15. d
16. e
17. b
18. a
19. b
20. c
21. c
22. t
23. t
24. t
25. f
26. f
27. t
28. f
29. f
30. f
31. b
32. d
33. b
34. c
35. e
36. c
37. e
38. c

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT V: MANUAL AND POWER RACK AND PINION STEERING GEAR SERVICE

UNIT OBJECTIVE

After completing this unit, the student should be able to service and adjust manual and power rack and pinion steering gears. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the procedures for inspecting the tie rods on rack and pinion steering assemblies (Competency R7, Part III of the Unit V Test).

II. Identify the procedures for removing and installing a manual rack and pinion steering gear (Competency R4, Part I of the Unit V Test).

III. Identify the procedures for disassembling and inspecting a manual rack and pinion steering gear (Competency R4, Part I of the Unit V Test).

IV. Identify the procedures for reassembling the manual rack and pinion steering gear (Competencies R4, R5, and R7, Parts I, II, and III of the Unit V Test).

V. Demonstrate the ability to:

   a. Remove and install a manual rack and pinion steering gear (Competency R4, JS1-L1-UV).

   b. Inspect and replace rack and pinion inner tie rods and bellows boots (Competency R7, JS2-L1-UV).

   c. Disassemble, clean, and inspect a manual rack and pinion steering gear (Competency R4, JS3-L1-UV).

   d. Reassemble and adjust a manual rack and pinion steering gear (Competency R4, JS4-L1-UV).

Lesson 2.

I. Identify the procedures for removing and installing a power rack and pinion steering gear (Competency R4, Part I of the Unit V Test).

II. Identify the procedures for disassembling and inspecting a power steering gear (Competency R4, Part I of the Unit V Test).

III. Identify the procedures for reassembling a power rack and pinion steering gear (Competencies R4, R5, and R7, Parts I, II, and III of the Unit V Test).

IV. Demonstrate the ability to:

  a. Remove and install a power rack and pinion steering gear (Competency R4, JS1-L2-UV).

  b. Disassemble, clean, and inspect a power rack and pinion steering gear (Competency R4, JS2-L2-UV).

  c. Reassemble and adjust a power rack and pinion steering gear (Competency R5, JS3-L2-UV).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D008-D012.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT V: MANUAL AND POWER RACK AND PINION STEERING GEAR SERVICE

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: MANUAL RACK AND PINION STEERING GEAR REPAIR

    a. Information outline

    b. Assignment sheets

        AS1-L1-UV: Procedures for Removing and Reinstalling a Manual Rack and Pinion Steering Gear
        AS2-L1-UV: Procedures for Removing and Reinstalling Rack and Pinion Steering Inner Tie Rods and Bellows Boots
        AS3-L1-UV: Procedures for Disassembling, Cleaning, and Inspecting a Manual Rack and Pinion Steering Gear
        AS4-L1-UV: Procedures for Reassembling and Adjusting a Manual Rack and Pinion Steering Gear

    c. Job sheets

        JS1-L1-UV: Removing and Installing a Manual Rack and Pinion Steering Gear
        JS2-L1-UV: Inspecting and Replacing Rack and Pinion Inner Tie Rods and Bellows Boots
        JS3-L1-UV: Disassembling, Cleaning, and Inspecting a Manual Rack and Pinion Steering Gear
        JS4-L1-UV: Reassembling and Adjusting a Manual Rack and Pinion Steering Gear

2. Lesson 2: POWER RACK AND PINION STEERING GEAR REPAIR

    a. Information outline

    b. Assignment sheets

        AS1-L2-UV: Procedures for Removing and Reinstalling a Power Rack and Pinion Steering Gear
        AS2-L2-UV: Procedures for Disassembling, Cleaning, and Inspecting a Power Rack and Pinion Steering Gear
        AS3-L2-UV: Procedures for Reassembling and Adjusting a Power Rack and Pinion Steering Gear

c. Job sheets

JS1-L2-UV: Removing and Installing a Power Rack and Pinion Steering Gear
JS2-L2-UV: Disassembling, Cleaning, and Inspecting a Power Rack and Pinion Steering Gear
JS3-L2-UV: Reassembling and Adjusting a Power Rack and Pinion Steering Gear

E. Unit test

F. Answers to unit test

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Toboldt, William K. and Johnson, Larry. Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair. South Holland, Illinois: The Goodheart-Willcox Company, Inc. 1981.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UV in conjunction with JS1-L1-UV; AS2-L1-UV in conjunction with JS2-L1-UV; AS3-L1-UV in conjunction with JS3-L1-UV; AS4-L1-UV in conjunction with JS4-L1-UV; AS1-L2-UV in conjunction with JS1-L2-UV; AS2-L2-UV in conjunction with JS2-L2-UV; AS3-L2-UV in conjunction with JS3-L2-UV.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT V: MANUAL AND POWER RACK AND PINION STEERING GEAR SERVICE

LESSON 1: MANUAL RACK AND PINION STEERING GEAR REPAIR

I. Inspecting the inner tie rod

(NOTE: Outer tie rods on rack and pinion systems should be inspected in much the same manner as conventional steering linkage outer tie rods are inspected.)

(NOTE: The inner tie rod sockets, however, can be difficult to check because they are concealed inside either rubber or soft plastic boots.)

(NOTE: The following procedure should be used when the technician wishes to make a quick inspection of the general condition of the inner tie rod. A more thorough inspection procedure is outlined below.)

- A. Squeeze the boot until the inner socket is felt.
- B. While squeezing the boot, have an assistant either turn the steering wheel back and forth 1/8 to 1/4 of a turn or push and pull on the tires, turning them in and out 1/4 of a turn. If the tie rod feels loose, replace it.
- C. Some inner tie rod boots are made of hard plastic, which is impossible to squeeze. To inspect hard plastic rod boots, lock the steering wheel and, using the proper equipment, lift the wheels off the ground.
- D. With the vehicle off the ground, turn the wheels in and out while watching for movement in the tie rods. If movement is detected, replace the tie rods.
- E. Outlined below is a more thorough tie rod inspection procedure.
    - 1. Remove the inner tie rod boot clamps and slide the boot back to expose the rod.
    - 2. Turn the steering wheel back and forth while the wheels are resting on the ground. Watch the sockets for movement. If movement is detected, replace the rod.

      (NOTE: Some manual steering gears will be filled with liquid lubricant which may be lost when the boot is removed. When checking inner tie rods on manual rack and pinion systems that contain liquid lubricant, do not remove the boot unless the entire assembly will be removed or the lubricant can be replaced.)

II. Removing and installing a manual rack and pinion steering gear

- A. Procedure for removing a manual rack and pinion steering gear
    - 1. Remove the pinch bolt or roll pin which connects the steering gear to the flexible coupling. The coupling will be located either under the hood or under the instrument panel.

(NOTE: Such items as the steering column boot or a sound deadener panel may have to be removed in order to access the coupling. Some vehicles will have a slip-type coupling that will slide apart as the rack is removed.)

2. Raise and secure the vehicle.

3. Remove the cotter pins and castellated nuts from the outer tie rod ends.

4. Disconnect the outer tie rod ends from the steering arms.

   (NOTE: Use a tie rod press and not a pickle fork for this procedure.)

5. Support the steering gear and remove the bolts that attach the steering gear to the vehicle.

6. Remove the steering gear from the vehicle.

   (NOTE: On some vehicles, the front tire and wheel assemblies will have to be removed before the steering gear is removed.)

   (NOTE: Instead of being removed from underneath the vehicle, some rack and pinion units must be removed through a hole in the inner fender and then taken out of the vehicle's side.)

B. Procedure for installing a manual rack and pinion steering gear

1. To install the rack and pinion gear, reverse the removal procedure.

2. Have an assistant guide the steering gear stub shaft into the flexible coupling as the gear assembly is raised into place.

3. Inspect the condition of the flexible coupling and replace it if defective.

4. Inspect the condition of any rubber mounting grommets and replace them as necessary.

5. Tighten all fasteners to the factory-recommended torque.

6. Check toe setting and adjust if necessary.

   (NOTE: The procedure for checking toe setting will be covered in a later unit.)

III. Disassembling and inspecting a manual steering gear

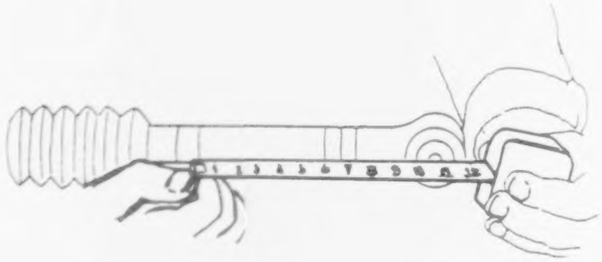
A. Thoroughly clean the exterior of the steering gear with safety solvent. If possible, place the rack and pinion gear in a holding fixture.

   (**CAUTION:** If the steering gear is clamped in a vise, be extremely careful not to over tighten the vise and destroy the steering gear.)

B. Disassemble the inner and outer tie rods according to the procedure outlined below.

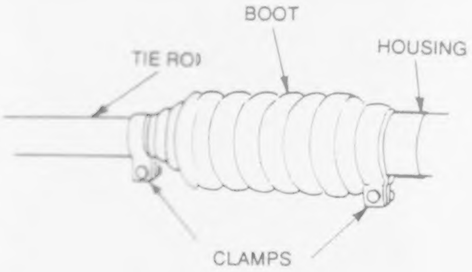
   (NOTE: Outer tie rods can be replaced without removing the rack and pinion; replacement of inner tie rods, however, may require the removal of the rack and pinion. Consult an appropriate service manual for specific procedures.)

1. Measure from the center of the outer tie rod to the boot retaining groove on the inner tie rod. Record this measurement for both the left and right sides. During reassembly, this measurement will give an approximate toe setting.



2. Loosen the outer tie rod jam nuts; then remove both the outer tie rod and the jam nuts.

3. Remove the four clamps holding the boots to the gear housing and tie rods. These clamps will usually be destroyed during removal.



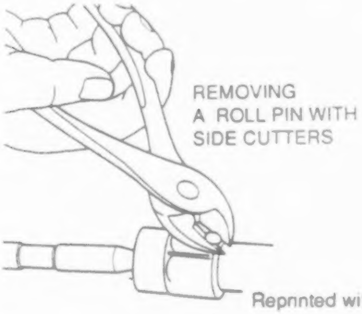
4. Drain the lubricant from the gear housing and remove the boots.

5. The inner tie rods are held in place by one of the four retaining devices listed below. The retaining devices must be removed before the tie rods are removed.

   a. Some inner tie rods are held in place by a soft-steel drill pin driven into a hole located between the inner tie rod and a jam nut. The pin prevents the jam nut from loosening. This pin must be drilled out before the inner tie rod can be removed.

   b. Staking is another method of retaining inner tie rods. After the inner tie rods are installed, they are staked or crimped in place. These tie rods can usually be removed with a wrench, but some must be unstaked with a chisel. All replacement rods must also be staked.

c. In some cases, the inner tie rods are locked in with a hollow roll pin, which is driven into the rod. To remove this type of tie rod, drive the roll pin out of the retainer assembly with a punch.



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d. A jam nut is sometimes tightened against the inner tie rod to hold it in place. The jam nut prevents the rod from backing off. The jam nut must be loosened in order to remove the tie rod.

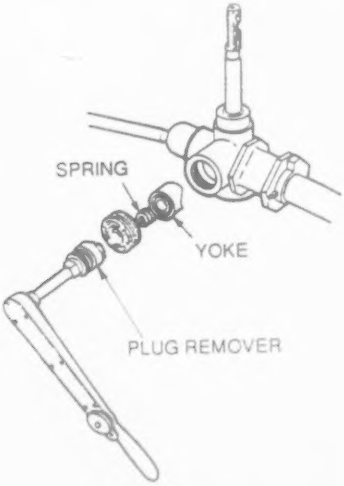
6. After the retaining device is removed, the inner tie rods may be screwed off the rack.

(**CAUTION:** As the tie rods are loosened, place an adjustable wrench on the rack to prevent the rack from turning. If the rack should twist, it may damage the pinion.)

(NOTE: If the rack required no other service, the new inner tie rod can be installed according to manufacturer's instructions.)

C. Disassemble rack and pinion according to the procedure outlined below.

1. Remove the yoke plug or cover and the spring and yoke (rack) bearing.



2. Remove pinion oil seal.

3. Remove pinion retainer and then remove the pinion and bearing.

   (NOTE: Check the service manual before removing the pinion. To prevent the steering from having an unequal number of turns in the right and left directions, some manufacturers require that a reference mark be made on the rack so that the position of the rack and pinion gears can be determined during unit reassembly.)

   (**CAUTION:** Once the pinion is removed, the rack may slide out of the housing.)

   a. Remove the pinion bearing from the pinion.

   b. On some units the bearing must be pressed off the pinion shaft.

4. Remove the rack from the gear housing.

5. Remove the rack bushing retainers and the housing bushings. A puller may be needed to remove the bushings from the housing. Be careful not to damage the housing when removing the bushings.

   (NOTE: Check the service manual before removing bushings. Some manufacturers require that the housing or the entire unit be replaced if the bushings are worn or damaged.)

6. Thoroughly clean all parts in safety solvent and blow them dry.

D. Inspecting the manual steering gear

   1. Check boots for deterioration or damage.

   2. Check the rack and pinion teeth for wear or damage.

   3. Check all bearings and bushings for wear or roughness.

   4. Check the housing for cracks or physical damage.

   5. Check condition of yoke spring.

IV. Procedures for reassembling the manual steering gear

   A. Coat all steering gear components with lubricant prior to reassembly. If the rack uses a lithium-based lubricant, the assembly will need to be packed with grease during reassembly.

   B. If rack bushings and retainers were removed, install them in the gear housing.

   C. Slide the rack into the housing. Be careful not to damage the bushings. The gear teeth should face the pinion and be parallel to the pinion shaft.

   D. Install the pinion and pinion bearings.

      1. The rack and pinion must be properly aligned if the steering is to be centered.

2. Depending on the manufacturer's recommendations, align the rack and pinion according to either the reference marks made during disassembly or the measurements given in the service manual.

3. Following the manufacturer's instructions, adjust the pinion bearings. Adjustment procedures will vary, depending on the manufacturer. Some of the more popular methods for adjusting pinion bearings are listed below.

   a. A threaded plug, called an adjuster plug, is used to adjust the pinion.

   b. Shims are added or removed to obtain the proper adjustment.

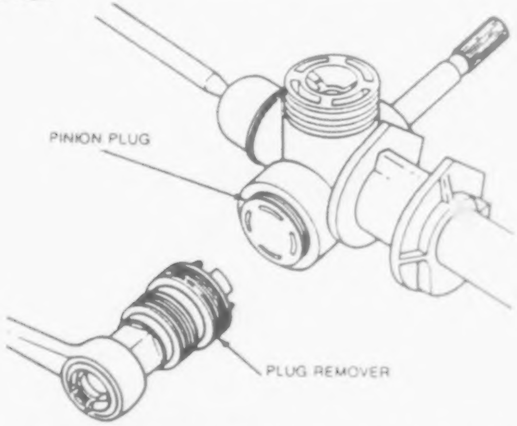
   c. Snap rings of different thicknesses are used to obtain the proper adjustment.

E. Install the pinion seal.

F. Install the yoke bearing and adjuster. The yoke adjusting procedures also vary.

1. During adjuster installation, some adjusters merely require that shims be added or removed to achieve the correct preload.

2. During installation of screw adjusters, a plug is screwed into the adjuster until it bottoms. The plug is then backed out a specific amount. The pinion turning torque is checked with a torque wrench. The plug may then be turned in or out as required to achieve the proper torque. The plug is then locked in place with a lock nut.



G. Install the tie rods according to the procedure outlined below.

1. Thread inner tie rod jam nuts and inner tie rods onto the rack.

   a. Tighten tie rods and jam nuts to the factory-specified torque.

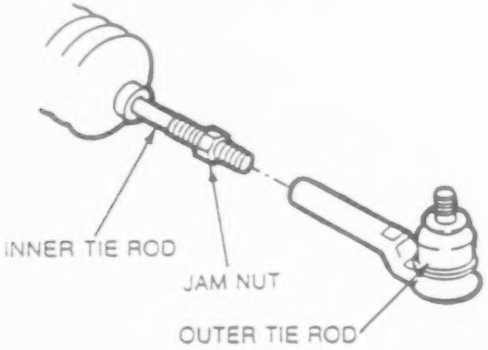
   b. Either install the roll or drill pin or stake the housing.

2. Install boots and clamps over inner tie rod sockets.

   a. If the manufacturer specifies a liquid lubricant, install only one boot and place the rack in a vertical position with the boot on the bottom. Fill the rack housing from the upper end with the correct amount of the specified lubricant. Then install the second boot.

   b. A special tool may be required to install the clamps.

3. Using the measurements taken before disassembly, install the outer tie rods and tighten jam nuts.



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MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REMOVING AND REINSTALLING A MANUAL RACK AND PINION STEERING GEAR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the manual rack and pinion steering gear.
3. Develop a written procedure for reinstalling the manual rack and pinion steering gear. Make sure the procedure includes all necessary torque specifications.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REMOVING AND REINSTALLING RACK AND PINION STEERING INNER TIE RODS AND BELLOWS BOOTS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for inspecting rack and pinion inner tie rods and bellows boots.
3. Develop a written procedure for removing the rack and pinion inner tie rods.
4. Develop a written procedure for reinstalling the rack and pinion inner tie rods. Make sure the procedure includes all necessary torque specifications.

AS3-L1-UV

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR DISASSEMBLING, CLEANING, AND INSPECTING A MANUAL RACK AND PINION STEERING GEAR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for disassembling the manual rack and pinion steering gear.
3. Develop a written procedure for cleaning and inspecting the manual rack and pinion steering gear.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REASSEMBLING AND ADJUSTING A MANUAL RACK AND PINION STEERING GEAR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model and year of the vehicle to be serviced.

2. Develop a written procedure for reassembling and adjusting the manual rack and pinion steering gear. Make sure the procedure includes all the necessary adjustments and torque specifications. Also make sure the procedure identifies the type of lubricant used in the rack and pinion steering gear.

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING A MANUAL RACK AND PINION STEERING GEAR

Equipment:

Hand tools
Hoist
Torque wrench
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. When necessary, place the vehicle securely on safety stands or lift with hoist. ___ ___ ___ ___

   (**CAUTION:** Always use proper equipment when lifting a vehicle.)

3. Complete AS1-L1-UV. Following the procedure developed in item 2 of AS1-L1-UV, remove the manual rack and pinion steering gear. Also make the inspections outlined below. ___ ___ ___ ___

   a. Inspect the gear assembly for lubricant leaks or housing damage. Record observations.

   b. Inspect the condition of the flexible coupling and rubber mounting bushings. Replace any worn or deteriorated parts. Record observations.

4. Following the procedure outlined in item 3 of AS1-L1-UV, reinstall the rack and pinion steering gear. ____

   a. Set the toe-in after lowering the vehicle. Ask the instructor for this procedure.

   b. Check operation of the steering gear. Record observations.

Average of above evaluations* ____

(*This average is a partial evaluation for Competency R4. Final evaluation for R4 will be made at the end of JS2-L2-UV.)

JS2-L1-UV

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING RACK AND PINION INNER TIE RODS AND BELLOWS BOOTS

Equipment:

Hand tools
Torque wrench
Serviceable vehicle
Hoist
Specialty tools
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Place the vehicle securely on safety stands or lift it with a hoist. ___ ___ ___ ___

   (**CAUTION:** Always use proper equipment when lifting a vehicle.)

3. Complete AS2-L1-UV. Following the procedure developed in item 2 of AS2-L1-UV, inspect the condition of the inner tie rods and bellows boots. Record observations. ___ ___ ___ ___

4. If required, follow the procedure developed in item 3 of AS2-L1-UV to remove the inner tie rod and bellows boot. ___ ___ ___ ___

   (NOTE: It may be necessary to remove the rack and pinion unit before removing the inner tie rod and bellows. If so, refer to JS1-L1-UV for the procedure.)

5. Following the procedure developed in item 4 of AS2-L1-UV, install the inner tie rods and bellows boots. Also perform the tasks outlined below. ___ ___ ___ ___

   a. Be sure to retain the inner tie rods in the factory-recommended manner.

   b. Tighten all fasteners to specified torque.

c. Set toe-in. See the instructor for this procedure.

d. Check operation of the steering system. Record observations.

Average of above evaluations* ___ ___ ___ ___

(*This average is a partial evaluation for Competency R7. Final evaluation for R7 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency R7 by averaging the evaluations of JS1-L2-UIII, JS2-L2-UIII, JS3-L2-UIII, JS4-L2-UIII, JS5-L2-UIII, JS6-L2-UIII, JS7-L2-UIII, and JS2-L1-UV. Use the spaces provided below.

	Evaluation 3	 2	 1	 N
JS1-L2-UIII	___	___	___	___
JS2-L2-UIII	___	___	___	___
JS3-L2-UIII	___	___	___	___
JS4-L2-UIII	___	___	___	___
JS5-L2-UIII	___	___	___	___
JS6-L2-UIII	___	___	___	___
JS7-L2-UIII	___	___	___	___
JS2-L1-UV	___	___	___	___
Final evaluation for Competency R7	___	___	___	___

MODULE: STEERING AND SUSPENSION SYSTEMS

DISASSEMBLING, CLEANING, AND INSPECTING A MANUAL RACK AND PINION STEERING GEAR

Equipment:

Hand tools
Drain pan
Vise or holding fixture
Specialty tools
Safety glasses

Procedure: Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Remove the steering gear from the vehicle, if required. Refer to JS1-L1-UV for this procedure. ___ ___ ___ ___

3. Complete AS3-L1-UV. Following the procedure developed in item 2 of AS3-L1-UV, disassemble the manual rack and pinion steering gear. Thoroughly clean the exterior of the steering gear with safety solvent. ___ ___ ___ ___

4. Following the procedure developed in item 3 of AS3-L1-UV, clean and inspect the manual rack and pinion steering gear. Use the following check list to identify any defective components. ___ ___ ___ ___

Gear housing	OK_____	NOT OK_____
Pinion	OK_____	NOT OK_____
Rack	OK_____	NOT OK_____
Pinion bearings	OK_____	NOT OK_____
Rack bearing	OK_____	NOT OK_____
Bellows boots	OK_____	NOT OK_____
Rack bushings	OK_____	NOT OK_____

Suggest appropriate procedures for correcting any problems identified in the above chart.

Average of above evaluations* ___ ___ ___ ___

(*This average is a partial evaluation for Competency R4. Final evaluation for R4 will be made at the end of JS2-L2-UV.)

MODULE: STEERING AND SUSPENSION SYSTEMS

REASSEMBLING AND ADJUSTING A MANUAL RACK AND PINION STEERING GEAR

Equipment:

Hand tools
Torque wrench
Vise or holding fixture
Torque wrench
Specialty tools
Safety glasses

Procedure: Evaluation 3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS4-L1-UV. Following the procedure developed in item 2 of AS4-L1-UV, reassemble the rack and pinion steering gear. ___ ___ ___ ___

    a. Make sure that all damaged or missing parts are replaced as directed by the instructor.

    (NOTE: Lightly coat all components with the appropriate gear lubricant during assembly. Steering gears using lithium lubricant should be packed during assembly.)

    b. Tighten all fasteners to factory-recommended torque.

    c. Fill the steering gear with the factory recommended lubricant.

3. Following the procedure developed in item 2 of AS4-L1-UV, adjust the manual rack and pinion steering gear. ___ ___ ___ ___

4. Turn the pinion shaft through a couple of full left to right turns. Note any binding or roughness. Record observations. ___ ___ ___ ___

5. Reinstall the steering gear on the vehicle, if required. For this procedure, refer to JS1-L1-UV. — — — —

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency R4. Final evaluation for R4 will be made at the end of JS2-L2-UV.)

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT V: MANUAL AND POWER RACK AND PINION STEERING GEAR SERVICE

LESSON 2: POWER RACK AND PINION STEERING GEAR REPAIR

I. Removing and installing a power rack and pinion steering gear

  A. Procedure for removing a power rack and pinion steering gear

  (NOTE: Determine the source of any fluid leaks before removing the power rack and pinion gear; doing so will help in diagnosing the unit as it is disassembled.)

    1. Remove either the pinch bolt or roll pin that connects the steering gear to the flexible coupling. The coupling may be located under either the hood or the instrument panel, depending on the vehicle's design. Items such as the steering column boot or the sound deadening panel must be removed to gain access to the coupling.

    (NOTE: Some vehicles have a slip-type coupling that slides apart as the rack is removed.)

    2. Raise and secure the vehicle.

    3. Remove the cotter pins and castellated nuts from the outer tie rod ends.

    4. Disconnect the outer tie rod ends from the steering arms.

    (NOTE: Use a tie rod press and not a pickle fork to remove the tie rod ends.)

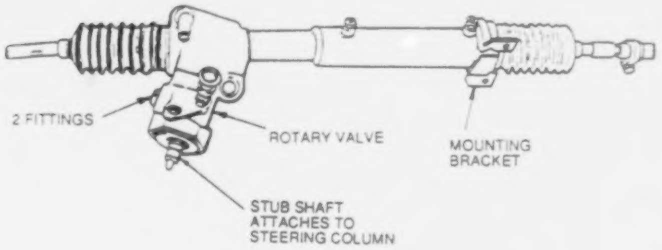
    5. Place a drain pan under the steering gear and disconnect the pressure and return fluid lines at the steering gear. Plug both the lines and the fluid ports on the gear housing.

    6. Support the steering gear and remove the bolts attaching the steering gear to the vehicle.

7. Remove the steering gear from the vehicle.

(NOTE: On some vehicles, the front tire and wheel assemblies must be removed before the steering gear is removed.)

(NOTE: Some rack and pinion units must be removed through a hole in the inner fender and then taken out of the vehicle's side.)



B. Procedure for installing a power rack and pinion steering gear

1. To install the rack and pinion gear, reverse the removal procedure.

2. Have an assistant guide the steering gear stub shaft into the flexible coupling as the gear assembly is raised into place.

3. Inspect the condition of the flexible coupling and replace it if defective.

4. Inspect the condition of any rubber mounting grommets and replace them as necessary.

5. Inspect and replace hoses that are deteriorated or leaking.

6. Tighten all fasteners to the factory-recommended torque.

7. Fill the fluid reservoir with the factory-recommended fluid and bleed the system as described in Unit II of this module.

8. Inspect for leaks and make repairs, if necessary.

9. Check toe-in setting and adjust if necessary.

(NOTE: The procedure for checking toe-in will be covered in a later unit.)

II. Disassembling and inspecting a power steering gear

A. Thoroughly clean the exterior of the steering gear with a safety solvent.

B. If possible, place the rack and pinion gear in a special holding fixture.

(**CAUTION:** If the steering gear is clamped in a vise, be extremely careful not to overtighten the vise and destroy the steering gear.)

C. Disassemble the inner and outer tie rods.

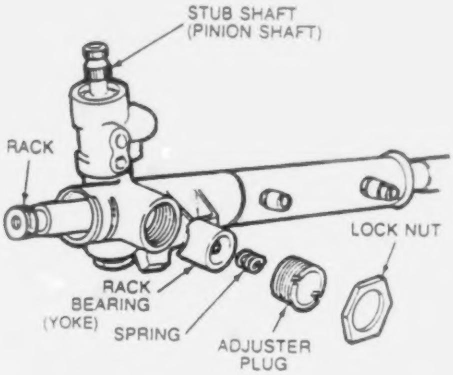
(NOTE: Tie rods on power rack and pinion units are serviced in the same manner as those on manual steering units. Refer to Lesson 1 of this unit for specific service procedures.)

(NOTE: A breather tube will connect both bellows boots. Mark the position of the breather tube on the gear housing before disassembly. The marks will be useful during reassembly.)

D. Disassemble the rack and pinion according to the procedure outlined below.

(NOTE: Each manufacturer of power rack and pinion steering units uses different designs. Though all rack and pinion units operate in a similar manner, service procedures vary. Special tools, such as pullers or seal installers, may be required to service some units. The procedure outlined below is very general. Consult the appropriate manual for specific procedures.)

1. Loosen the adjuster plug lock nut and remove the adjuster plug, the spring, and the rack bearing.



2. Remove the pinion shaft and control valve assembly according to the procedure outlined below.

   a. Rotate the pinion shaft until the rack is centered in the housing. Mark the housing where flat on the stub shaft is located. This mark will be used for reference during reassembly.

   b. Remove the stub shaft retaining ring.

   c. Remove the dust cover and lock nut from the pinion shaft.

   d. Remove the stub shaft seal.

   e. Remove the pinion and valve assembly.

   f. Remove the old sealing rings from the control valve. Be careful not to damage the control valve.

3. Remove the rack from the housing.

   (NOTE: Mark the rack with a position location reference so that the rack can be correctly positioned during reassembly.)

   a. Remove the bulkhead retaining ring.

   b. Remove the rack and bulkhead.

   c. Remove the inner rack seal from the housing.

   d. Remove the piston ring from the rack.

4. Disassemble the housing.

   a. Remove the pinion bearing from the housing.

   b. Remove the pinion bushing and seal.

   c. Mark the position of the breather tube for reassembly.

   d. Remove the breather tube.

   e. Remove the cylinder lines and o-rings.

E. Inspect the power steering gear according to the procedure outlined below.

1. Clean all parts in safety solvent and blow dry.

2. Inspect the gear housing.

   a. Inspect the hoses for cracks and porosity.

   b. Inspect the control valve bore for wear or scoring.

   c. Inspect the rack piston bore for wear, pitting, or scoring.

   d. Make sure all fluid passages are open and clean.

   e. Inspect the condition of the cylinder lines and fittings.

3. Inspect the rack.

   a. Inspect the rack teeth for chipping or wear.

   b. Inspect the piston for nicks or burrs.

   c. Inspect all seal and bearing surfaces for roughness or wear.

   d. Inspect the tie rod threads on the rack for wear. Make sure threads are not stripped.

4. Inspect the valve and pinion assembly.

   a. Inspect the pinion gear for wear or chipping.

b. Inspect the valve spool for wear or nicks and scratches. Light scratches may be polished with crocus cloth.

c. Inspect shaft bearing and seal surfaces for wear or scoring.

(NOTE: With the exception of the sealing rings on the valve spool, the valve and pinion assembly is serviced as a complete unit.)

5. Inspect all bushings and bearings for wear or roughness and replace them if necessary.

III. Reassembling a power rack and pinion steering gear

(NOTE: Each manufacturer of power rack and pinion steering units uses different designs. Though all rack and pinion units operate in a similar manner, service procedures vary. Special tools, such as pullers or seal installers, may be required to service some units. The procedure outlined below is very general. Consult the appropriate manual for specific procedures.)

(NOTE: Coat all parts with power steering fluid before reassembly.)

A. Install the cylinder tubes in the gear housing.

1. Use new o-rings on the tubes.

2. Tighten the fittings to specified torque. Be careful not to crossthread or overtighten the fittings in the aluminum housing.

B. Install the upper pinion bushing and a new pinion seal in the gear housing.

C. Install the lower bearing of the pinion shaft and the retainer in the gear housing.

D. Carefully install a new piston ring on the rack. Place a seal protector over the rack teeth. Next, slide the inner rack seal over the rack teeth and bottom the seal against the piston. Remove the protector.

E. Slide the rack and seal into the housing. Seat the inner seal by tapping the end of the rack with a soft-faced mallet.

F. Place seal protector over the rack and install the bulkhead, the seal, and the retaining ring. Then remove the seal protector.

G. Install new seals on the control valve.

H. Center the rack in the housing and install the pinion and control valve assembly. Align the pinion shaft with the mark made during disassembly.

I. Install the stub shaft bearing, the seal, the dust seal and retaining ring.

J. Hold the pinion in position; install and torque the lock nut.

K. Install the rack bearing. Next install the spring and adjuster. Turn the adjuster clockwise until it bottoms; then, back off the adjuster a specified amount. Hold the adjuster position and tighten the lock nut to the specified torque.

L. Install tie rods as previously outlined.

   1. To prevent gear damage, be sure to prevent the rack from turning while tightening the tie rods.

   2. Align the breather tube with the marks made during disassembly. Reinstall the tube.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REMOVING AND REINSTALLING A POWER RACK AND PINION STEERING GEAR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.

2. Develop a written procedure for removing the power rack and pinion steering gear.

3. Develop a written procedure for reinstalling the power rack and pinion steering gear. Make sure the procedure includes all necessary torque specifications. Also make sure to record the type of power steering fluid used in the gear.

AS2-L2-UV

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR DISASSEMBLING, CLEANING, AND INSPECTING A POWER RACK AND PINION STEERING GEAR

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for disassembling the power rack and pinion steering gear.
3. Develop a written procedure for cle[illegible] and inspecting the power rack and pinion steering gear.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REASSEMBLING AND ADJUSTING A POWER RACK AND PINION STEERING GEAR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for reassembling and adjusting the power rack and pinion steering gear. Make sure the procedure includes all specifications related to adjustment and reassembly. Also make sure to record the type of power steering fluid used in the gear.

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING A POWER RACK AND PINION STEERING GEAR

Equipment:

Drain pan
Hand tools
Hoist
Torque wrench
Safety glasses

Procedure:

	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	_ _ _ _
2. When necessary, place the vehicle securely on safety stands or lift it with a hoist.	_ _ _ _
(**CAUTION:** Always use proper equipment when lifting a vehicle.)	
3. Complete AS1-L2-UV. Following the procedure developed in item 2 of AS1-L2-UV, remove the power rack and pinion steering gear.	_ _ _ _

a. Clean all dirt from around fluid line connections at the steering gear. Doing so will prevent the power steering system from becoming contaminated when the lines are disconnected.

b. Remove both fluid lines from the steering gear. Plug both the fluid lines and the steering gear ports.

c. Inspect the gear assembly for fluid leaks and housing damage. Record observations.

d. Inspect the condition of rubber mounting bushings and grommets. Inspect the condition of the flexible coupling. Replace any defective parts. Record observations.

e. Inspect the pressure and return hoses. Record observations.

4. Following the procedure developed in item 3 of AS1-L2-UV, install the power rack and pinion steering assembly. ____

    a. Be sure all defective parts are replaced as directed by the instructor.

    b. Fill the steering reservoir with the factory-recommended fluid and bleed the system.

    c. After lowering the vehicle, check and adjust toe-in. See the instructor for this procedure.

    d. Check operation of the power steering system. Record observations.

Average of the above evaluations* ____

(*This average is a partial evaluation for Competency R4. Final evaluation for R4 will be made at the end of JS2-L2-UV.)

MODULE: STEERING AND SUSPENSION SYSTEMS

DISASSEMBLING, CLEANING, AND INSPECTING A POWER RACK AND PINION STEERING GEAR

Equipment:

Hand tools
Drain pan
Vise or holding fixture
Specialty tools
Safety glasses

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Remove the steering gear from the vehicle, if required. For this procedure, refer to JS1-L2-UV.	__ __ __ __
3. Complete AS2-L2-UV. Following the procedure developed in item 2 of AS2-L2-UV, disassemble the power rack and pinion steering gear.	__ __ __ __
a. Plug fluid ports and thoroughly clean the exterior of the steering gear with a safety solvent. (NOTE: Some steering gears contain components that cannot be serviced. Manufacturers of these gears recommend that the gears not be disassembled. Closely follow the manufacturer's disassembly procedures and recommendations for the gear to be serviced.)	
4. Following the procedure developed in item 3 of AS2-L2-UV, clean and inspect the steering linkage components.	__ __ __ __
a. Thoroughly clean all parts in clean safety solvent and blow them dry.	

b. Use the following check list to identify any defective components found during the inspection. Add components to the list if necessary.

Gear housing	OK____	NOT OK____
Rack	OK____	NOT OK____
Pinion and control	OK____	NOT OK____
Valve assembly	OK____	NOT OK____
Pinion bearings	OK____	NOT OK____
Rack bearing	OK____	NOT OK____
Bulkhead	OK____	NOT OK____
Seals	OK____	NOT OK____
Rack bushings	OK____	NOT OK____

Suggest the proper procedures for correcting any problems identified in the above check list.

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competency R4. Final evaluation for R4 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency R4 by averaging the evaluations of JS1-L1-UV, JS3-L1-UV, JS4-L1-UV, JS1-L2-UV, and JS2-L2-UV. Use the spaces provided below.

	Evaluation 3 2 1 N
JS1-L1-UV	__ __ __ __
JS3-L1-UV	__ __ __ __
JS4-L1-UV	__ __ __ __
JS1-L2-UV	__ __ __ __
JS2-L2-UV	__ __ __ __
Final evaluation for Competency R4	__ __ __ __

JS3-L2-UV

MODULE: STEERING AND SUSPENSION SYSTEMS

REASSEMBLING AND ADJUSTING A POWER RACK AND PINION STEERING GEAR

Equipment:

Hand tools
Torque wrench
Vise or holding fixture
Specialty tools
Safety glasses

Procedure: Evaluation 3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS3-L2-UV. Following the procedure developed in item 2 of AS3-L2-UV, reassemble the steering gear. ___ ___ ___ ___

   a. Be sure that all damaged or missing parts discovered when performing JS2-L2-UV have been replaced as directed by the instructor.

   b. Lightly coat all components with the appropriate power steering fluid during assembly.

3. Following the procedure developed in item 2 of AS3-L2-UV, adjust the steering gear. ___ ___ ___ ___

4. Turn the pinion through several complete left-to-right turns. Note any binding or roughness. Record observations. ___ ___ ___ ___

5. Reinstall the rack and pinion steering gear on the vehicle if required. For this procedure, refer to JS1-L2-UV. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the final evaluation for Competency R5.)

MODULE: STEERING AND SUSPENSION SYSTEM

UNIT V: MANUAL AND POWER RACK AND PINION SERVICE

UNIT V TEST

PART I. CLEANING AND INSPECTING POWER RACK AND PINION STEERING GEARS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. Some rack and pinion units are removed through the fire wall.

____ 2. The exterior of the steering gear should be thoroughly cleaned with gasoline before disassembly.

____ 3. Power rack and pinion parts should be cleaned with gasoline before assembly.

____ 4. A hammer and punch set is all that is required for most rack and pinion repairs.

____ 5. During steering gear disassembly, the rack is usually removed before the pinion.

____ 6. The source of all fluid leaks should be found before the power rack unit is removed.

____ 7. Before steering gear assembly, the technician should evaluate the condition of the steering gear components.

____ 8. A measurement is usually taken between the outer tie rod and pinion assembly before the steering linkage is disassembled.

____ 9. On some vehicles, the whole housing must be replaced if the rack bushings are destroyed.

____ 10. The rack can be removed without removing the bellows boots.

SECTION B. **Select the best answer from the five choices listed.**

____ 11. An accurate way to inspect the inner tie rods for looseness is to

a. lock the steering column and shake the wheels.
b. hold the wheels and shake the steering wheel.
c. remove the rack and pinion unit from the vehicle.
d. slide the boot back and observe the tie rod.
e. remove the pitman arm and check the play.

____ 12. Rack and pinion steering gears should not be held in a vise without a special holding fixture because the steering gear

a. could fall out.
b. may damage the vise.
c. could be ruined if the vise is overtightened.
d. housing may shatter when it is struck.
e. lubricant will be lost.

____ 13. During rack and pinion disassembly, the technician should inspect

a. the boots.
b. the pinion and rack teeth.
c. the bushings and bearings.
d. the housing.
e. all of the above

____ 14. When disassembling and inspecting a power rack and pinion steering gear, the technician must make sure that the breather tube is marked for

a. proper reassembly.
b. possible use on another vehicle.
c. proper disposal.
d. possible long-term storage.
e. none of the above.

____ 15. Damaged bushings should be

a. polished with crocus.
b. lightly filed.
c. discarded and replaced.
d. re-sized to fit the shaft.
e. patched or welded.

____ 16. After installing the rack and pinion assembly, the technician should check the

a. camber.
b. caster.
c. steering axis inclination.
d. toe measurement.
e. ride height.

(NOTE: The student must obtain a minimum score of _____ on Part I of the Unit V Test in order to receive an evaluation for Competency R4.)

PART II. REASSEMBLING AND ADJUSTING RACK AND PINION STEERING GEARS

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 17. Power rack and pinion parts should be lubricated with automatic transmission fluid before assembly.

____ 18. During steering gear reassembly, all parts should be coated with the lubricant found in the steering gear.

____ 19. Special tools are sometimes needed to install bellows boot clamps.

____ 20. The outer tie rods do need to be disconnected before the rack and pinion steering gear is removed.

____ 21. During the installation of tie rod ends, the rack should be prevented from moving.

____ 22. During steering gear assembly, the pinion is usually installed before the rack.

SECTION B. **Select the best answer from the five choices listed.**

____ 23. During assembly of the steering gear, the control valve should receive new

a. spool valves.
b. seals.
c. bushings.
d. bearings.
e. torsion bars.

____ 24. When repairing the rack and pinion steering gear, the technician should always use great care when placing the housing in the vise because the

a. vise could be damaged.
b. housing could be damaged.
c. rack could be damaged
d. pinion could be damaged.
e. tires could be damaged.

____ 25. During reassembly of the manual rack and pinion steering gear, liquid lubricant should be added

a. only after both boots are in place and secure.
b. only after one boot is in place and secure.
c. through the control valve hole.
d. only after the unit is mounted on the vehicle.
e. after the steering gear has been bled.

____ 26. After rebuilding the power rack and pinion steering gear, the technician should install

a. the inner tie rods.
b. the bellows boots.
c. the outer tie rods.
d. the gear into the vehicle.
e. all of the above.

(NOTE: The student must obtain a minimum score of _____ on Part II of the Unit V Test in order to receive an evaluation for Competency R5.)

PART III. INSPECTING AND REPLACING STEERING LINKAGE COMPONENTS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 27. Inspection procedures for outer tie rods in rack and pinion steering systems are much like inspection procedures for tie rods on conventional steering systems.

____ 28. Inner tie rod ends with hard plastic boots are inspected with the same procedure that is used for inspecting inner tie rod ends with soft plastic boots.

____ 29. Several methods can be used to retain inner tie rods on rack and pinion systems.

____ 30. The boots that cover outer tie rod ends can make boot inspection difficult.

____ 31. Before the outer tie rod is removed from the rack, a jam nut must be loosened.

____ 32. Inner and outer tie rod ends should not show any signs of damage.

____ 33. Pop rivets are sometimes used to hold tie rod retainers in place.

____ 34. Inner tie rod ends are difficult to inspect because of their location.

____ 35. The boots on a manual rack and pinion system should not be removed unless the entire assembly will be removed.

(NOTE: The student must obtain a minimum score of _____ on Part III of the Unit V Test in order to receive an evaluation for Competency R7.)

ANSWERS UNIT V TEST

1. t
2. f
3. f
4. f
5. t
6. t
7. t
8. t
9. t
10. f
11. d
12. c
13. e
14. a
15. c
16. d
17. f
18. t
19. t
20. t
21. t
22. f
23. b
24. b
25. b
26. e
27. t
28. f
29. t
30. f
31. t
32. t
33. f
34. f
35. t

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VI: POWER STEERING PUMP SERVICE AND DIAGNOSIS

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and service power steering pumps and check power steering system pressure. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the equipment needed for testing power steering systems (Competency R8, Unit VI Test).

II. Identify the procedures for hooking up the power steering testing equipment (Competency R8, Unit VI Test).

III. Identify the procedures for checking power steering system pressure (Competency R8, Unit VI Test).

IV. Demonstrate the ability to:

   a. Test power steering system pressure (Competency R8, JS1-L1-UVI).

Lesson 2.

I. Identify the procedures for removing and replacing a power steering pump (Competency R8, Unit VI Test).

II. Identify the procedures for servicing power steering hoses (Competency R8, Unit VI Test).

III. Identify the procedures for servicing a power steering pump (Competency R8, Unit VI Test).

IV. Demonstrate the ability to:

   a. Remove and install a power steering pump (Competency R8, JS1-L2-UVI).

   b. Remove and replace a power steering pressure hose (Competency R8, JS2-L2-UVI).

   c. Service a power steering pump (Competency R8, JS3-L2-UVI).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D016-D020.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VI: POWER STEERING PUMP SERVICE AND DIAGNOSIS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: PRESSURE TESTING POWER STEERING SYSTEMS

    a. Information outline

    b. Assignment sheet

      AS1-L1-UVI: Procedures for Pressure Testing a Power Steering System

    c. Job sheet

      JS1-L1-UVI: Testing Power Steering System Pressure

  2. Lesson 2: POWER STEERING PUMP AND HOSE SERVICE AND REPLACEMENT

    a. Information outline

    b. Assignment sheets

      AS1-L2-UVI: Procedures for Removing and Installing a Power Steering Pump, Inspecting Mountings, and Adjusting Belt Tension
      AS2-L2-UVI: Procedures for Removing and Replacing a Power Steering Pressure Hose
      AS3-L2-UVI: Procedures for Servicing a Power Steering Pump

    c. Job sheets

      JS1-L2-UVI: Removing and Installing a Power Steering Pump
      JS2-L2-UVI: Removing and Replacing a Power Steering Pressure Hose
      JS3-L2-UVI: Servicing a Power Steering Pump

E. Unit test

F. Answers to unit test

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UVI in conjunction with JS1-L1-UVI; AS1-L2-UVI in conjunction with JS1-L2-UVI; AS2-L2-UVI in conjunction with JS2-L2-UVI; and AS3-L2-UVI in conjunction with JS3-L2-UVI.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VI: POWER STEERING PUMP SERVICE AND DIAGNOSIS

LESSON 1: PRESSURE TESTING POWER STEERING SYSTEMS

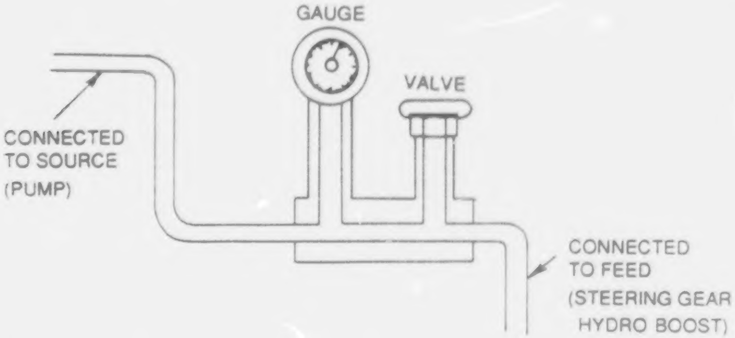
I. Equipment needed for testing power steering systems

A. Hydraulic pressure gauge capable of reading from 0 to 2000 pounds per square inch of pressure

B. Hydraulic hose with adapters to fit various vehicles

C. Shutoff valve to control flow of power steering fluid

(NOTE: Depending on the equipment manufacturer, the gauge, hoses, and valves listed above can be thought of as either individual components or as components that make up a single tester.)


GAUGE
VALVE
CONNECTED TO SOURCE (PUMP)
CONNECTED TO FEED (STEERING GEAR HYDRO BOOST)

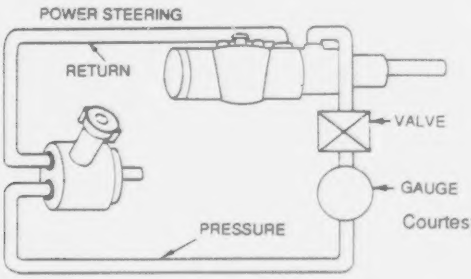
II. Hooking up power steering testing equipment

A. Procedure for hooking up test equipment to power steering systems

(NOTE: The procedure below applies to vehicles that do not use a hydraulic brake booster.)

1. Clean dirt from around the pressure line fitting at the power steering pump.

2. Place the drain pan under the power steering pump and disconnect pressure outlet line.


POWER STEERING
RETURN
VALVE
GAUGE
PRESSURE

Courtesy of Moog Automotive, Inc.

3. Remove the pressure hose from the power steering pump.

4. Using the appropriate adapters, connect the tester hose to the pump outlet.

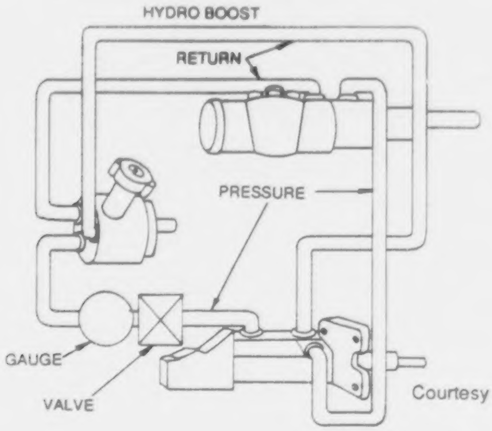
5. Using the proper adapters, connect the vehicle pressure hose (previously removed from the pump) to the outlet side of the tester shutoff valve.

   (**CAUTION:** Never use hoses or adapters that are not suitable for the high pressure encounter in the power steering systems. If a hose were to burst or a fitting were to come loose, bystanders could be severely burned by hot power steering oil.)

6. Open shutoff valve completely.

7. Add fluid and bleed air from the system, using the procedures outlined in Unit II of this module.

B. On vehicles with hydraulic power brakes, the power steering system provides pressure to both the power steering and the hydraulic brake booster. Procedures for hooking up test equipment to these systems are the same as those for standard power steering systems. Power steering systems that incorporate power brake boosters do, however, require different air bleeding procedures. These procedures are outlined below.



Courtesy of Moog Automotive, Inc.

1. Adjust fluid level in the same manner as for a standard power steering system.

2. With the engine running, apply the brakes until all air is expelled from the hydro-boost valve.

3. Stop the engine and add fluid if necessary. Restart the engine.

4. Turn the steering wheel from side to side several times.

   (NOTE: Avoid turning the wheel all the way to the stops.)

5. Once again stop the engine and add fluid if necessary. Restart the engine.

6. Depress the brake pedal several times while turning the steering wheel from side to side.

7. Once again stop the engine and pump the brake pedal four to five times. Add fluid if required and restart engine.

8. Repeat the above steps until fluid is at the full level.

III. Checking power steering system pressure

(NOTE: Perform the test procedures outlined below with the power steering system test equipment connected and the engine running at an idle.)

A. Check pump flow pressure against manufacture's recommendations. If pressure is in excess of 200 psi, check hoses for restrictions in the steering gear poppet valve.

B. Procedure for checking pump relief pressure (all makes of vehicles)

1. Completely close test valve and then open it. Perform this procedure three times. Record highest pressure noted each time the valve is opened and closed.

   (**CAUTION:** Do not hold the valve closed for more than five seconds; doing so could damage the pump.)

2. If the highest pressures noted during each of the three readings are within manufacturer's specifications and if the range of each reading is within 50 psi, the pump is functioning normally.

3. If the flow control valve is sticking, the pressure recorded during the first test will be high; the pressure recorded during a second test, however, will not fall within 50 psi of the reading from the first test. Repair or replace the valve as necessary.

4. If the pressures recorded are constant but below specifications, replace the flow control valve. If the pressures are still low, replace the pump.

C. Procedures for determining problems in the steering gear (integral), power cylinder and control valve (linkage type), and hydro-boost valve

1. If pump performance is within specifications when the test valve is open, turn the steering wheel to both the left and right stops and record the highest pressures. Compare these readings with maximum pump output.

2. If pump output can be repeated at either side of the stops, the entire system is satisfactory.

3. If pump output cannot be repeated, the steering gear, power assist cylinder, and control valve or hydro-boost valve are leaking internally.

4. Disconnect the pump pressure hose attached to the hydro-boost valve; also disconnect the pressure hose that connects the hydro-boost valve to the power steering gear.

   (NOTE: While the engine is off, pump the brake pedal several times to be sure that all pressure is discharged from the accumulator prior to disconnecting the hoses from the booster.)

5. Connect the two hoses so that the hydro-boost unit is bypassed.

   (**CAUTION:** The vehicle will not have power-assisted brakes while the hydro-boost unit is bypassed.)

6. Fill reservoir with the specified fluid and bleed system.

7. Turn the steering wheel to both the left and right stops and record the highest pressures. Compare these readings with maximum pump output. If the pressure reading equals pump output, steering gear is satisfactory and hydro-boost unit is faulty. If the pressure reading cannot equal pump output, steering gear is faulty and hydro-boost unit is satisfactory.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR PRESSURE TESTING A POWER STEERING SYSTEM

Instructions: **Do the following tasks on a separate sheet of** paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Draw a diagram which shows the way in which the pressure tester will be connected to the vehicle.
3. Determine and record all pressure specifications related to the power steering system.
4. Determine and record the type of power steering fluid used in the vehicle.
5. Determine and record the torque specifications for the power steering hose fittings on the vehicle.

MODULE: STEERING AND SUSPENSION SYSTEMS

TESTING POWER STEERING SYSTEM PRESSURE

Equipment:

Adapter hose and fittings
Drain pan
Hand tools
0-2000 psi pressure gauge
Shutoff valve
Safety valve
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS1-L1-UVI. Following the diagram developed in item 2 of AS1-L1-UVI, attach a pressure gauge and shutoff valve to the outlet side of the pump. Open the shutoff valve completely. ___ ___ ___ ___

   (NOTE: Be sure to clean around the fittings before removing them. Doing so will prevent fluid contamination.)

3. Fill the pump reservoir with the correct fluid and bleed the system. See the text of this lesson for bleeding procedures. ___ ___ ___ ___

4. With the tester valve still open, operate the engine at idle speed and read the gauge. The reading indicates the pump flow pressure. The reading should be within the specifications determined in item 3 of AS1-L1-UVI. Record the pressure below. ___ ___ ___ ___

   _______ psi

5. Close the test valve completely and then reopen it three times. Record the pressure each time the test valve is opened and closed. ___ ___ ___ ___

   (**CAUTION:** Do not hold the valve closed for more than five seconds. Doing so could damage the pump.)

   1. _______ psi

   2. _______ psi

   3. _______ psi

   (NOTE: All three readings should be within 50 psi of each other and within manufacturer's specifications for pump relief pressure. See item 3 of AS1-L1-UVI for specifications.)

6. Turn the steering wheel to the left and right stops and record the highest pressure. — — — —

   Left stop __________ psi

   Right stop _________ psi

   (NOTE: The pressure recorded at both steering stops should meet pump output pressure.)

   (NOTE: If the vehicle is equipped with hydro-boost brakes and does not pass the test under item 6 above, the hydro-boost unit will have to be bypassed to isolate the cause of the problem.)

7. Disconnect the pressure test equipment from the vehicle. — — — —

8. Fill the power steering reservoir with the correct fluid and bleed the system. — — — —

9. Using the results of the above tests, describe the condition of the power steering system below. If any problems were discovered during the test, suggest appropriate repair procedures. — — — —

(Average of above evaluations*) — — — —

(*This average is a partial evaluation for Competency R8. Final evaluation for R8 will be made at the end of JS3-L2-UVI.)

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VI: POWER STEERING PUMP SERVICE AND DIAGNOSIS

LESSON 2: POWER STEERING PUMP AND HOSE SERVICE AND REPLACEMENT

I. Removing and replacing a power steering pump

- A. Procedure for removing a power steering pump
    1. Loosen adjustment brackets and remove the belt from the power steering pump pulley.
    2. Disconnect the pressure hoses and return fluid hoses.
        - a. Clean dirt from around hose fittings before removing the hoses. Doing so will help to prevent contamination of the system.
        - b. Place a drain pan under the vehicle to catch the fluid.
        - c. After the lines are disconnected, plug the pressure and return lines and the pump ports.
    3. Remove the bolts attaching the pump to the engine.
        - a. Depending on the application, one or more of the mounting brackets may be removed with the pump.
        - b. After the bolts are removed, remove the pump from the vehicle.
- B. Procedure for inspecting a power steering pump
    1. Remove the dipstick and drain the fluid from the reservoir. If the pump has a separate reservoir, the fluid will not have to be drained.
    2. Replace the dipstick. While the fluid ports are still plugged, clean the exterior of the pump with safety solvent and inspect the pump pulley, reservoir, mounting brackets, and drive belts as outlined below.
    3. Inspect pump pulley.
        - a. Visually inspect the pulley for dents or cracks.
        - b. Turn the pulley and watch for excessive wobble.
        - c. If any defects are found, replace the pulley.

          (NOTE: Replacement pumps generally are not equipped with a pulley. The old pulley must be removed and installed on the new pump. The old pulley should, therefore, be inspected carefully.)

4. Inspect the reservoir.

    a. Inspect the reservoir for cracks or large dents.

    b. If the reservoir is defective, replace it.

    (NOTE: Replacement pumps may or may not be equipped with a reservoir. Before installing an old reservoir on a new pump, make sure the reservoir is in good condition.)

5. Inspect mounting brackets.

    a. Inspect for bent or cracked mounting brackets.

    b. If the mounting bracket incorporates a screw-type belt adjuster, make sure the adjuster operates smoothly.

    c. Replace any broken, cracked, or bent mountings.

6. Inspect drive belt.

    a. Inspect the belt for glazing, fraying, or cracking.

    b. If the belt is defective, replace it.

C. Removing and installing a pulley

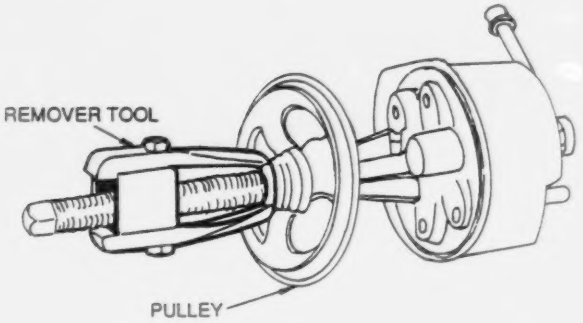
1. Procedure for removing a pulley

    a. Install a suitable pulley removal tool on the pulley hub.

    b. Place the removal tool in a bench vise with the pump pointing upward.

    c. Hold the pump and rotate the removal tool nut counterclockwise to remove the pulley.

    (NOTE: Do not apply inward or outward pressure on the pulley shaft to remove or install the pulley. Doing so will cause internal pump damage.)



2. Procedure for installing a pulley

   a. Place the pulley against the pump shaft. Screw the installation tool into the threaded hole in the pump shaft.

   b. Place the end of the tool in the vise with the pump extending upward.

   c. Hold the pump and turn the tool nut to install the pulley on the pump shaft.

   d. The pulley is usually installed flush with the end of the pump shaft.

D. Removing and installing the reservoir

1. Procedure for removing the reservoir

   a. Support the pump housing securely in a vise or holding fixture.

      (NOTE: Do not clamp the shaft in a vise.)

   b. Remove the outlet fitting and o-ring.

   c. Remove any other retaining bolts.

   d. Using a wood block and a hammer (or a soft-faced hammer), tap around the flange of the reservoir to release it from the pump.

      (NOTE: Never tap around the flange with a steel hammer or pry directly on the reservoir.)

   e. Remove and discard the pump to reservoir o-ring.

   f. Thoroughly clean the reservoir in safety solvent and blow dry.

      (NOTE: To remove fiberglass-reinforced nylon reservoirs, grasp the reservoirs on both sides and twist them back and forth. Do not hammer on fiberglass-reinforced reservoirs with a wood block.)

2. Procedure for installing a reservoir

    a. Install a new reservoir o-ring seal and outlet fitting gasket on the pump housing.

    b. Coat the inside edge of the reservoir and the o-ring with petroleum jelly.

    c. Place the reservoir over the pump housing and carefully align all holes.

    d. Tap the reservoir into place with a hammer and a block of wood.

    e. Install all retainers and tighten them to specified torque.

E. Procedure for pump installation

1. If any mounting brackets were removed along with the pump, install them on the pump housing.

2. Install the pump on the vehicle.

    a. Tighten all mounting fasteners to a specified torque.

    b. Leave adjuster bolts loose at this time.

3. Attach pressure and return lines and tighten to specified torque.

4. Place the drive belt over the pulley.

F. Procedure for adjusting belts

1. A belt tension gauge tool is needed to adjust the belt accurately.

2. Place the tension gauge on the drive belt, midway between the pulleys. Note the tension reading on the gauge. Compare this reading to the specification in the service manual and adjust the belt accordingly.

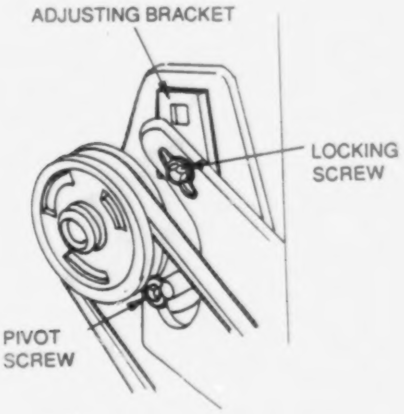
3. Adjust the belt by sliding the pump on the slotted holes in the bracket. Some of the more popular methods of sliding the pump are listed below.

    a. Some vehicles have a screw-type adjuster that moves the pump inward or outward in the slotted holes.

    b. Other vehicles require that the pump be pried inward or outward before it can be moved in or out of the slotted holes.

c. In still other vehicles, the pump bracket has a hole into which a tool may be inserted for pump removal.

(**CAUTION:** Never pry on the reservoir. Doing so may dent or crack the reservoir.)



II. Servicing power steering hoses

A. Hoses should be inspected for the following problems: dampness and leakage at crimp joints, abnormal swelling, abrasions, or cracks. Also note if hoses have a soft or spongy feel, which is a sign of internal deterioration.

B. Procedure for replacing a hose

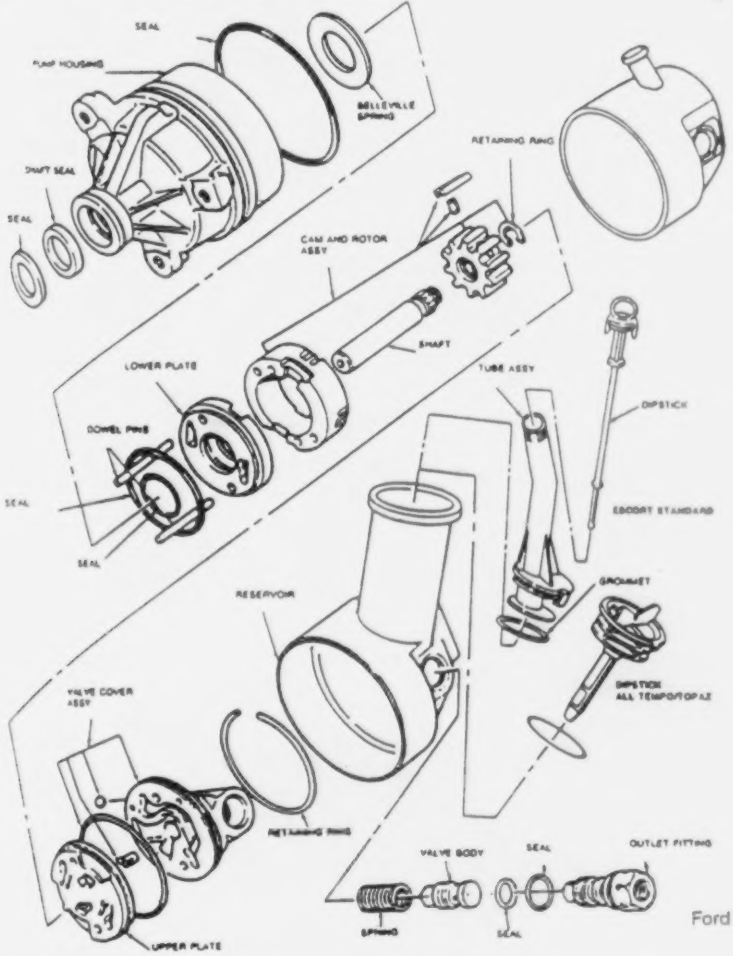
1. Thoroughly clean areas around hose connections to prevent contamination of the system.
2. Carefully check hose routing before removal.
3. Tighten all hose fittings to the factory-specified torque.
4. Always replace any o-rings.
5. Fill and bleed the power steering system.
6. Inspect system for leakage.

III. Servicing a power steering pump

A. Procedure for disassembling a power steering pump

1. Clean pump and remove pulley and reservoir as outlined earlier in this lesson.
2. Remove the flow control valve.
3. Remove end cover retainer. Remove end cover and spring from the housing.
4. Remove the pressure plate, rotor, cam ring, and thrust plate from the housing.
5. Remove and discard end cover o-rings and pressure plate o-rings.

6. Pry out shaft seal and discard it.


SEAL
PUMP HOUSING
BELLEVILLE SPRING
SHAFT SEAL
SEAL
RETAINING RING
CAM AND ROTOR ASSY
SHAFT
LOWER PLATE
TUBE ASSY
DIPSTICK
DOWEL PINS
SEAL
SEAL
ESCORT STANDARD
GROMMET
RESERVOIR
DIPSTICK ALL TEMPO/TOPAZ
VALVE COVER ASSY
RETAINING RING
VALVE BODY
SEAL
OUTLET FITTING
SPRING
SEAL
UPPER PLATE

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B. Procedure for cleaning and inspecting a power steering pump

1. Clean all parts in safety solvent and blow them dry.

2. Procedure for inspecting a power steering pump

   a. Inspect shaft and bushings for wear or damage.

   b. Inspect the rotor assembly and cam ring, the thrust and pressure plates, and all other internal parts for wear, scoring, or other damage.

   c. Replace any worn or damaged parts. Always install new seals and gaskets.

C. Procedures for reassembling a power steering pump

1. Assemble the power steering pump in reverse order of disassembly.

2. Coat all parts with power steering fluid during reassembly.

3. To prevent cutting o-rings during assembly, coat o-rings and mating surfaces with petroleum jelly.

4. Install a new shaft seal using a suitable driver.

5. Tighten all fasteners to specified torque.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REMOVING AND INSTALLING A POWER STEERING PUMP, INSPECTING MOUNTINGS, AND ADJUSTING BELT TENSION

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the power steering pump.
3. Develop a written procedure for cleaning and inspecting the power steering pump and mountings.
4. Develop a written procedure for installing the power steering pump and adjusting drive belt tension.
5. Record the type of power steering fluid used in the vehicle.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REMOVING AND REPLACING A POWER STEERING PRESSURE HOSE

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the power steering pressure hose and installing a new one. Make sure the procedure includes all necessary torque specifications related to replacement of the hose.
3. Record the type of power steering fluid used in the vehicle.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR SERVICING A POWER STEERING PUMP

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for disassembling and reassembling the pump. Make sure the procedure includes all necessary torque specifications.
3. Determine and record all other tolerances related to the servicing of the power steering pump.

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING A POWER STEERING PUMP

Equipment:

Hand tools
Drain pan
Belt tension gauge
Torque wrench
Specialty tools
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS1-L2-UVI. Following the procedure developed in item 2 of AS1-L2-UVI, remove the power steering pump. ___ ___ ___ ___

   a. Before removing the pump, be sure to clean around the hose fittings to prevent contamination of the system.

   b. After removing the pump, be sure to plug the hose fittings on the pump fluid ports.

3. Following the procedure developed in item 3 of AS1-L2-UVI, clean and inspect the power steering pump. Use the following check list to indicate problems with the pump. ___ ___ ___ ___

   Pulley OK____NOT OK____
   Reservoir OK____NOT OK____
   Mountings OK____NOT OK____
   Hoses OK____NOT OK____
   Drive belt OK____NOT OK____

4. If necessary, change the pulley that drives the new pump. Use the proper tools. ___ ___ ___ ___

5. Following the procedure outlined below, replace the reservoir, if necessary. ___ ___ ___ ___

   a. Support the pump housing in a vise or holding fixture while the reservoir is being changed.

   b. Remove the reservoir by tapping it with a block of wood and a hammer or by grasping and twisting it back and forth.

c. Clean the reservoir thoroughly and install a new pump housing to the reservoir o-ring.

d. Coat the o-ring with petroleum jelly and install the reservoir on the new pump.

(NOTE: Do not hammer on reservoirs made of fiberglass-reinforced nylon.)

6. Following the procedure developed in item 4 of AS1-L2-UVI, install the power steering pump. ____

a. Adjust the power steering drive belt to the specified tension.

b. Tighten all fasteners to the specified torque.

c. Fill the power steering reservoir with the correct fluid and bleed the system.

d. Inspect for and correct any leaks.

Average of above evaluations* ____

(*This average is a partial evaluation for Competency R8. Final evaluation for R8 will be made at the end of JS3-L2-UVI.)

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND REPLACING A POWER STEERING PRESSURE HOSE

Equipment:

Hand tools
Torque wrench
Hoist
Safety glasses

Procedure: Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. If necessary, place the vehicle securely on safety stands or lift it with a hoist. __ __ __ __

3. Complete AS2-L2-UVI. Following the procedure outlined in item 2 of AS2-L2-UVI, remove the power steering hose. __ __ __ __

    a. Thoroughly clean the area around the hose fittings before removing the hose; doing so will prevent the fluid from becoming contaminated.

    b. To make reassembly easier, note the manner in which the hose is routed.

4. Following the procedure outlined in item 2 of AS2-L2-UVI, replace the power steering hose. __ __ __ __

    a. Tighten fittings to specified torque.

    b. Fill reservoir with specified fluid and bleed system.

    c. Check for and repair any leaks.

    d. Inspect the installation carefully to make sure the hose is not routed against a pulley, a hot exhaust manifold, or any other items which could damage the hose.

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competency R8. Final evaluation for R8 will be made at the end of JS3-L2-UVI.)

JS3-L2-UVI

MODULE: STEERING AND SUSPENSION SYSTEMS

SERVICING A POWER STEERING PUMP

Equipment:

Hand tools
Torque wrench
Specialty tools
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. If required, remove the pump from the vehicle. Refer to JS1-L2-UVI for this procedure. __ __ __ __

3. Complete AS3-L2-UVI. Following the procedure outlined in item 2 of AS3-L2-UVI, disassemble the power steering pump. __ __ __ __

4. Thoroughly clean all the steering pump components in safety solvent and blow them dry. Inspect the components. Use the chart below to indicate any problems with the components. __ __ __ __

   Housing OK____ NOT OK____
   Rotor OK____ NOT OK____
   Shaft OK____ NOT OK____
   Reservoir OK____ NOT OK____
   Pulley OK____ NOT OK____
   Pressure plate OK____ NOT OK____
   Thrust plate OK____ NOT OK____
   Vanes OK____ NOT OK____
   Cam ring OK____ NOT OK____

   Suggest appropriate steps of procedure for any item marked "NOT OK" on the above chart.

5. Following the procedure developed in item 2 of AS1-L2-UVI, reassemble the pump. __ __ __ __

   a. Be sure that all damaged or defective pump components have been replaced as directed by the instructor.

   b. Tighten all fasteners to the specified torque.

      (NOTE: Lightly coat all components with the appropriate power steering fluid during assembly.)

   c. After assembly, manually rotate shaft and check pump for binding. Shaft should rotate freely. Some manufacturers give a turning torque specification for shaft rotation.

6. Reinstall the power steering pump on the vehicle, if required. For this procedure, refer to JS1-L2-UVI. __ __ __ __

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competency R8. Final evaluation for R8 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency R8 by averaging the evaluations of JS1-L1-UVI, JS1-L2-UVI, JS2-L2-UVI, and JS3-L2-UVI. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L1-UVI	__	__	__	__
JS1-L2-UVI	__	__	__	__
JS2-L2-UVI	__	__	__	__
JS3-L2-UVI	__	__	__	__
Final evaluation for Competency R8	__	__	__	__

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VI: POWER STEERING PUMP SERVICE AND DIAGNOSIS

UNIT VI TEST

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. If used to check power steering systems, a hydraulic pressure gauge should be capable of reading between 0 to 100 psi.

____ 2. Power steering system pressure is determined by measuring return line pressure.

____ 3. A vehicle must be running before its power steering system pressure is checked.

____ 4. The results of a power steering system pressure test can help determine whether a problem is in the power steering pump or steering gear.

____ 5. The tension of a power steering pump belt is usually set by prying on the reservoir.

____ 6. Hydro-boost power brakes use engine coolant to reduce the effort required to stop the vehicle.

____ 7. On vehicles with hydro-boost, pressure must be discharged from the system before test hoses are removed.

____ 8. A belt tension gauge is usually not needed to adjust power steering pump belts.

____ 9. To compensate for stretching, fan belts should be adjusted as tightly as possible.

____ 10. Because of high replacement costs, bent pulleys on power steering pumps should be straightened and reused if possible.

____ 11. Most replacement power steering pumps come complete with new pulleys.

____ 12. Pulleys on power steering pumps are usually hammered flush with the end of the pump shaft during installation.

____ 13. When removing a fiberglass-reinforced pump reservoir, the technician should be careful not to damage the pump housing when hammering on the reservoir.

____ 14. When removing the power steering pump reservoir, the technician should never clamp the pump shaft in a vise.

SECTION B. Select the best answer from the five choices listed.

____ 15. When inspecting power steering hoses, the technician should look for

a. cracks.
b. dampness and leakage at crimp points.
c. abnormal swelling.
d. soft or spongy feel.
e. all of the above.

____ 16. When replacing power steering hoses, the technician should

a. check hose routing.
b. make sure that the correct type of hose is being installed.
c. tighten all connections to factory specifications.
d. fill and bleed the power steering system.
e. all of the above.

____ 17. To prevent o-rings from being cut during assembly, the technician should coat them with

a. lithium grease.
b. power steering fluid.
c. chassis grease.
d. petroleum jelly.
e. wheel bearing grease.

____ 18. During power steering pressure tests, the technician should not hold the valve closed for more than

a. 5 seconds
b. 10 seconds
c. 15 seconds
d. 20 seconds
e. 30 seconds

____ 19. Pump flow pressure (except on Chrysler and Ford vehicles) should be a minimum of

a. 180 psi.
b. 170 psi.
c. 150 psi.
d. 130 psi.
e. 110 psi.

____ 20. The power steering pump pulley should be inspected for

a. dents, cracks, and wobble.
b. wobble, cracks, and burns.
c. cracks, dents, and noise.
d. dents, glazing, and slippage.
e. cracks, dents, and glazing.

(NOTE: The student must obtain a minimum score of ____ on the Unit VI Test in order to receive an evaluation for Competency R8.)

ANSWERS TO UNIT VI TEST

1. f
2. f
3. t
4. t
5. f
6. f
7 t
8. f
9. f
10. f
11. f
12. f
13. f
14. t
15. e
16. e
17. d
18. a
19. c
20. a

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VII: STEERING COLUMN INSPECTION AND REPAIR

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and repair steering columns. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the function of the energy-absorbing steering column (Competency R6, Unit VII Test).

II. Identify the four principal components of an energy-absorbing steering column (Competency R6, Unit VII Test).

Lesson 2.

I. Identify the procedures for diagnosing steering column problems (Competency R6, Unit VII Test).

II. Identify the procedures for removing and reinstalling a steering column (Competency R6, Unit VII Test).

III. Identify the procedures for servicing a steering column (Competency R6, Unit VII Test).

IV. Demonstrate the ability to:

   a. Diagnose steering column problems and remove and install an energy-absorbing steering column (Competency R6, JS1-L2-UVii).

   b. Disassemble, inspect, and reassemble an energy-absorbing steering column (Competency R6, JS2-L2-UVII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D001 and D004.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VII: STEERING COLUMN INSPECTION AND REPAIR

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

   1. Lesson 1: OPERATION AND DESIGN OF THE ENERGY-ABSORBING STEERING COLUMN

      a. Information outline

   2. Lesson 2: STEERING COLUMN SERVICE AND DIAGNOSIS

      a. Information outline

      b. Assignment sheets

         AS1-L2-UVII: Procedures for Removing and Installing a Steering Column
         AS2-L2-UVII: Procedures for Disassembling, Inspecting, and Reassembling an Energy-Absorbing Steering Column

      c. Job sheets

         JS1-L2-UVII: Diagnosing Steering Column Problems and Removing and Installing an Energy-Absorbing Steering Column
         JS2-L2-UVII: Disassembling, Inspecting, and Reassembling an Energy-Absorbing Steering Column

E. Unit test

F. Answers to unit test

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Toboldt, William K. and Johnson, Larry. Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair. South Holland, Illinois: The Goodheart-Willcox Company, Inc. 1981.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L2-UVII in conjunction with JS1-L2-UVII and AS2-L2-UVII in conjunction with JS2-L2-UVII.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VII: STEERING COLUMN INSPECTION AND REPAIR

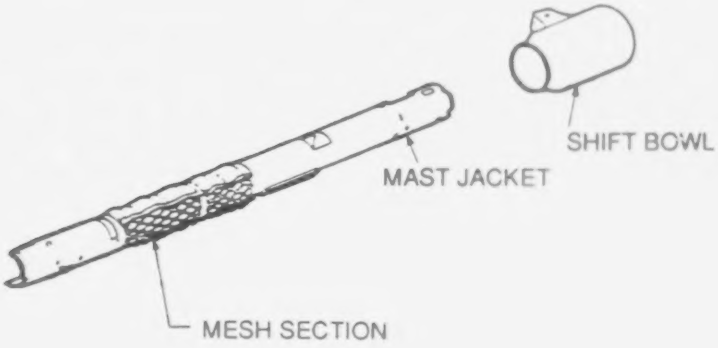
LESSON 1: OPERATION AND DESIGN OF THE ENERGY-ABSORBING STEERING COLUMN

I. All late-model vehicles use an energy-absorbing or collapsible steering column. During a frontal collision, the steering column compresses and reduces its tendency to move the steering wheel toward the rear of the vehicle. The column will also absorb the force of the driver's body being thrown against the steering wheel.

II. Four principal components of the energy-absorbing steering column

   A. Column jacket (mast) is the outer shell or housing of the steering column. The jacket houses and supports the steering shaft and other internal components of the column.

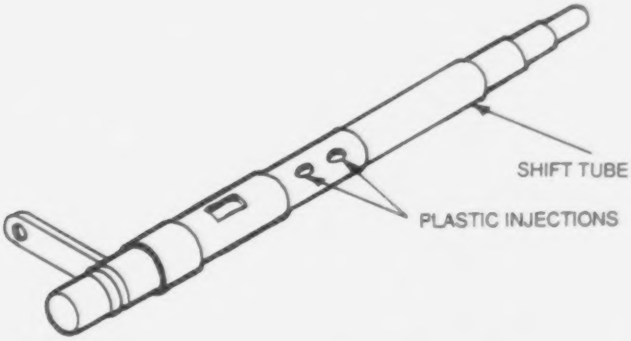
      1. Some column jackets have a slotted mesh section that rolls up at the lower end upon impact, thus shortening the column.



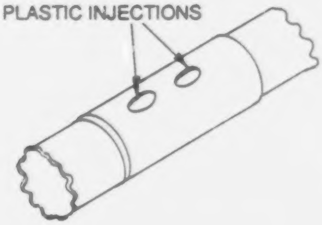
      2. Other column jackets consist of two sections; steel balls imbedded in plastic are placed between these sections. Upon impact, the plastic is sheared and the two sections telescope together.

B. The gear shift tube is a hollow tube that fits over the steering shaft and connects the gear shift lever to the gear shift linkage at the base of the steering column. The tube is made of two pieces and held in position by injected plastic. Upon impact, the plastic is designed to shear, allowing the tube to telescope.

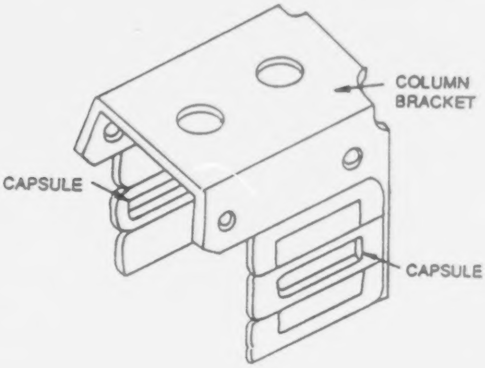
(NOTE: Not all vehicles use column-mounted gear shifters.)



C. The steering shaft connects the steering wheel to the steering gear. The steering shaft consists of a solid upper shaft inserted into a hollow lower shaft. The lower section of the upper shaft is double-flatted. The lower shaft is formed to fit over the double-flatted section of the upper shaft. (The double-flatted section allows the vehicle to be steered even though the column is completely telescoped.) Plastic is injected into the hollow lower shaft and into grooves in the solid shaft. Upon impact, the plastic shears, causing the shaft to collapse.



D. The column mounting bracket is located under the instrument panel. The brackets will allow the column to slide forward while blocking any movement of the column toward the rear of the vehicle (i.e. toward the driver). Each mounting bracket incorporates two breakaway capsules. The capsules allow the bracket to slip off the attaching points, permitting the steering column to compress in a forward direction.



MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VII: STEERING COLUMN INSPECTION AND REPAIR

LESSON 2: STEERING COLUMN SERVICE AND DIAGNOSIS

I. Diagnosing steering column problems

  A. Steering column defects can cause problems throughout the steering system. A few of these steering system problems are listed below.

    1. Bad steering shaft bearings can increase the amount of effort required to turn the steering wheel.

    2. A rattle in the steering column might be caused by broken plastic in the collapsible steering shaft.

    3. A broken shift tube can cause the transmission to operate improperly.

  B. Steering columns can have many different problems. Many service manuals have a diagnosis chart to help the technician correctly diagnose the problem.

II. Removing and reinstalling a steering column

  A. Procedure for removing a steering column

    1. Disconnect the negative battery cable.

    2. Remove clamp bolt from the flexible coupling at the lower end of the column shaft.

    3. Disconnect the shift linkage from the shift tube at the lower end of the steering column.

    4. Remove the steering wheel (only if the steering column is to be serviced after it is out of the car).

      a. Remove horn pad assembly and disconnect horn wires.

      b. Remove steering wheel nut retainer and attaching nut.

      c. Using a suitable steering wheel puller, remove the steering wheel.

      (NOTE: Never remove a steering wheel by hitting the end of the steering shaft with a hammer; doing so may damage the energy-absorbing column.)

    5. Remove the floor plate to the floor pan attaching screws.

    6. Remove the trim cover from the lower instrument panel.

    7. Remove the shift indicator needle or cable from the shift bowl.

    8. Remove all wiring harness connections.

9. Remove the nuts from the brackets that support the column. These brackets are located under the instrument panel.

    a. Support the column while removing the nuts.

    b. Lower column and unplug wiring connectors.

    (NOTE: Note the positioning of any spacers used in the column mounting bolts.)

10. Carefully remove the steering column from the vehicle.

    (NOTE: Once removed from the car, the steering column is extremely susceptible to damage. Dropping the column on its end could collapse the steering shaft or loosen the plastic injections. Leaning on the column assembly could bend or deform the jacket. Such damage could impair the column's ability to collapse on impact. If the steering wheel must be removed, use a standard wheel puller. Never hammer on the end of the shaft; doing so could loosen the plastic injections, which maintain column rigidity.)

B. Procedure for installing the steering column

1. Carefully position the steering column from inside the car through the cowl.

2. Connect all wiring before raising the steering column.

3. Raise the steering column and install any spacers. Install the nuts loosely to support bracket bolts.

4. Install the flexible coupling clamp bolt and tighten to specified torque.

5. Inspect the flexible coupling alignment. If necessary, move the column to align it.

6. Install and torque the floor pan screws.

7. Tighten the instrument panel support bracket nuts to the specified torque.

8. Install the gear shift indicator needle or cable.

9. Install the trim cover on the lower instrument panel.

10. Install the steering wheel.

    a. Align the marks on the steering shaft and steering wheel hub and position the wheel on the shaft.

    b. Install the wheel nut and tighten to specified torque.

    c. Install the steering wheel nut retainer.

    d. Connect the horn wires and install steering wheel pad.

11. Connect the negative battery cable.

(NOTE: Failing to tighten bolts to the specified torque or installing bolts that are too long could render an energy-absorbing steering column ineffective.)

III. Servicing a steering column

(NOTE: The following two procedures are very general in nature. Due to the large variety of steering column designs, it is impossible to list a service procedure for each one. Consult the appropriate service manual for the specific vehicle to be serviced.)

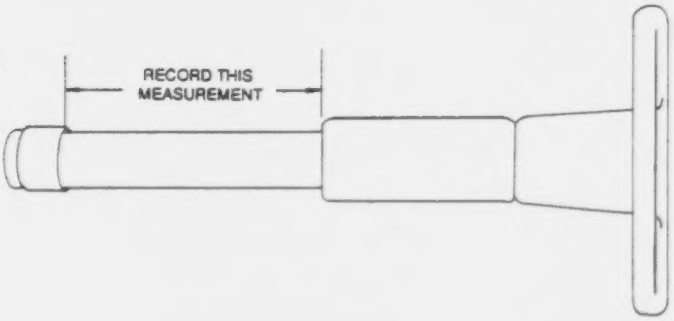
A. Procedure for disassembling the steering column

1. Remove the steering column from the vehicle as outlined above.
2. Remove the steering wheel.
3. Remove the steering wheel lock plate and turn the signal canceling cam.
4. Remove the turn signal switch.
5. Remove the ignition lock cylinder and key warning buzzer switch.
6. Remove the ignition switch, backup light switch, and dimmer switch.
7. Remove the wiper switch and steering column housing.
8. Remove the gear shift lever, lever bowl, and shift bowl shroud.
9. Remove the steering shaft and shift tube from mast jacket.

B. Procedure for inspecting steering column components

1. Make sure that the two-piece steering shaft is straight and that the plastic injections are secure.
2. Inspect the bearings for looseness or damage.
3. Inspect the shift tube and shift bowl for wear or breakage.
4. Inspect the tilt mechanism for wear or damage.

5. If the steering column has been impacted during an accident, the steering column and steering shaft should be carefully inspected for signs of collapsing. The steering column mounting bracket capsules should also be inspected for movement. The following diagram shows one manufacturer's procedure for determining if a column has been damaged in an accident.



C. Procedure for reassembling the steering column

1. To assemble the steering column, reverse the disassembly procedure.
2. Be sure to tighten all fasteners to specified torque.
3. Prior to assembly, lubricate bearings with multipurpose grease.
4. Adjust all switches according to the manufacturer's instructions.

D. Some steering column service procedures can be performed without removing the column from the vehicle. Some of these procedures are listed below.

1. Steering wheel removal and installation
2. Turn signal switch replacement
3. Ignition switch replacement
4. Gear shift lever replacement

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REMOVING AND INSTALLING A STEERING COLUMN

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the steering column.
3. Develop a written procedure for installing the steering column. Make sure the procedure includes all necessary torque specifications.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR DISASSEMBLING, INSPECTING, AND REASSEMBLING AN ENERGY-ABSORBING STEERING COLUMN

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for disassembling the steering column.
3. Develop a written procedure for assembling the steering column. Make sure the procedure includes all necessary torque specifications.

MODULE: STEERING AND SUSPENSION SYSTEMS

DIAGNOSING STEERING COLUMN PROBLEMS AND REMOVING AND INSTALLING AN ENERGY-ABSORBING STEERING COLUMN

Equipment:

Hand tools
Steering wheel puller
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Inspect the operation of the steering column. Answer the below questions. In the space below the questions, suggest procedures to correct any problems found during the inspection. __ __ __ __

    a. Does the steering wheel lock correctly?

    Yes_____ No_____

    b. Does the ignition switch operate correctly?

    Yes_____ No_____

    c. Is the amount of effort required to turn the steering wheel appropriate? (If the vehicle has power steering, start the engine before performing this test.)

    Yes_____ No_____

    d. Are there any unusual noises when the steering wheel is turned? (If the vehicle has power steering, start the engine before performing this test.)

    Yes_____ No_____

    e. Does the column shift lever operate correctly? (This question applies only to vehicles using column shifters.)

    Yes_____ No_____

    f. Does the tilt mechanism operate correctly? (This question applies only to vehicles equipped with a tilt mechanism.)

    Yes_____ No_____

g. Does the column seem to be loose while the steering wheel is being turned?

Yes_____ No_____

3. Complete AS1-L2-UVII. Following the procedure developed in item 2 of AS1-L2-UVII, remove the steering column. _ _ _ _

4. Inspect the column assembly. Answer the below questions. In the space after the questions, suggest procedures to correct any problems found during the inspection. _ _ _ _

a. Does the flexible coupling exhibit signs of wear?

Yes_____ No_____

b. Do the column mountings exhibit signs of looseness or cracking?

Yes_____ No_____

c. Are there any loose grommets on the shift linkage?

Yes_____ No_____

5. Following the procedure developed in item 3 of AS1-L2-UVII, reinstall the steering column. _ _ _ _

a. Make sure any spacers used on the mounting brackets are reinstalled in their proper locations.

b. Tighten all fasteners to specified torque.

c. Check the alignment of the flexible coupling.

6. After the steering column has been installed, start the engine and inspect the column as outlined below. Be sure to obtain the instructor's permission before making the checks, however. _ _ _ _

a. Put the gear shift in all positions and watch for any problems in the column. Record observations.

b. Watch for any problems in the column while turning the steering wheel through left and right turns. Record observations.

c. Check operation of all electrical devices in the steering column. Record observations.

Average of above evaluations* ____

(*This average is a partial evaluation for Competency R6. Final evaluation for R6 will be made at the end of JS2-L2-UVII.)

JS2-L2-UVII

MODULE: STEERING AND SUSPENSION SYSTEMS

DISASSEMBLING, INSPECTING, AND REASSEMBLING AN ENERGY-ABSORBING STEERING COLUMN

Equipment:

Hand tools
Specialty tools
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. _ _ _ _

2. If required, remove the steering column from the vehicle. Refer to JS1-L2-UVII for this procedure. _ _ _ _

3. Complete AS2-L2-UVII. Following the procedure developed in item 2 of AS2-L2-UVII, disassemble the steering column. _ _ _ _

   (NOTE: Do not drop the steering column or hammer on the steering shaft; doing so could collapse the steering column or loosen the plastic injections.)

4. Inspect the steering column. Use the below check list to indicate problems with steering column components. _ _ _ _

   Mast jacket OK_____ NOT OK_____
   Steering shaft OK_____ NOT OK_____
   Shift tube OK_____ NOT OK_____
   Shift bowl OK_____ NOT OK_____
   Steering shaft bearings OK_____ NOT OK_____
   Wheel lock mechanism OK_____ NOT OK_____
   Tilt mechanism OK_____ NOT OK_____

   Suggest repair procedures for any components marked "NOT OK."

5. Following the procedure developed in item 3 of AS2-L2-UVII, assemble the steering column. _ _ _ _

   a. Tighten all fasteners to specified torque.

   b. Replace all defective or missing parts as directed by the instructor.

c. Adjust all switches as directed in the service manual.

6. Reinstall the steering column in the vehicle, if required. Refer to JS1 L2-UVII for this procedure. _ _ _ _

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency R6. Final evaluation for R6 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency R6 by averaging the evaluations of JS1-L2-UVII and JS2-L2-UVII. Use the spaces provided below.

	Evaluation 3 2 1 N
JS1-L2-UVII	_ _ _ _
JS2-L2-UVII	_ _ _ _
Final evaluation for Competency R6	_ _ _ _

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VII: STEERING COLUMN INSPECTION AND REPAIR

UNIT VII TEST

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. All late-model passenger cars are equipped with an energy-absorbing steering column.

____ 2. The energy-absorbing steering column has three principal components.

____ 3. Bad steering shaft bushings could cause a column transmission shifter to malfunction.

____ 4. Before replacing a steering column, the technician should disconnect the battery.

____ 5. The steering column should be handled carefully to prevent damage to the energy-absorbing device.

____ 6. When removing the steering column, the technician should also remove the steering wheel.

____ 7. When inspecting the column for possible collision damage, the technician should check the length of the column and the mounting brackets.

____ 8. Ignition switch replacement usually requires the removal of the steering column.

____ 9. A puller should be used to remove the steering wheel.

____ 10. The outer shell or housing of the steering column is called the shift tube.

____ 11. The shift tube is usually connected to the auto body by means of mounting brackets.

____ 12. Lead injections are used to maintain column rigidity.

____ 13. Steering column bearings are lubricated with petroleum jelly.

____ 14. Before removing the steering column, the technician should remove the flexible coupler.

____ 15. Spacers are used to align the steering column with the shift tube.

____ 16 Bad steering shaft bearings can cause the steering wheel to fall off.

SECTION B. **Select the best answer from the five choices listed.**

____ 17. During frontal collisions, the energy-absorbing steering column will

a. reduce the tendency of the column to move toward the driver.
b. absorb the force of the driver's body as it contacts the steering wheel.
c. slip off the mounting brackets.
d. shear the injections in the steering shaft.
e. do all of the above.

___ 18. The principal components of the energy-absorbing steering column are the

a. column, shift tube, steering shaft, and brackets.
b. shift tube, jacket, steering wheel, and coupling.
c. column, jacket, steering shaft, steering wheel, and brackets.
d. column, jacket, steering shaft, steering wheel, and coupling.
e. jacket, shift tube, steering tube, and electrical harness.

___ 19. Steering column mounting brackets allow the column to move

a. backward but not forward.
b. forward but not backward.
c. forward and backward.
d. left and right.
e. left only.

___ 20. The technician should connect the wiring to the steering column after the

a. battery has been connected.
b. steering column has been bolted in place.
c. floor pan screws have been torqued down.
d. flexible coupling alignment has been set.
e. vehicle's radio has been installed.

___ 21. Using the incorrect bolts on the steering column brackets could

a. cause sluggish steering.
b. cause hard steering.
c. cause the columns's electrical wires to melt.
d. render the steering column unable to absorb energy.
e. render the steering system useless in high-speed maneuvers.

___ 22. Slotted mesh is usually used on

a. steering wheels.
b. steering tubes.
c. steering jackets.
d. steering brackets.
e. none of the above.

___ 23. If the steering shaft is completely telescoped,

a. the vehicle will stall.
b. all steering control will be lost.
c. the transmission will shift to neutral.
d. the brakes will lock up.
e. none of the above will occur.

___ 24. One switch not found in the steering column is the

a. dimmer switch.
b. headlight switch.
c. cruise control.
d. tilt control.
e. emergency brake.

____ 25. When the driver contacts the steering wheel during an impact, the steering column

a. collapses.
b. remains solid.
c. impales the drive.
d. explodes.
e. does none of the above.

____ 26. Vehicles that sustain frame damage and major body or sheet metal damage should be checked for

a. steering column bracket damage.
b. misalignment of the steering column.
c. impacted steering shaft.
d. impacted steering column.
e. all the above.

SECTION C. Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.

____ 27. Technician I says that most steering column problems are a result of accidents.

Technician II says that if a vehicle has been involved in a major accident, the steering column should be inspected.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 28. Technician I says that the steering column is usually hammered off the flexible coupling.

Technician II says that the steering column must be removed to repair the turn signal switch.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 29. Technician I says that a vehicle's steering columns are usually replaced after 100,000 miles.

Technician II says that when the steering column is fully telescoped, the vehicle will stall.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 30. Technician I says that the steering wheel is removed with a puller.

Technician II says that the steering column should never be lowered out through the fire wall.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of ____ on the Unit VII Test in order to receive an evaluation for Competency R6.)

ANSWERS TO UNIT VII TEST

1. t
2. f
3. f
4. t
5. t
6. t
7. t
8. f
9. t
10. f
11. f
12. f
13. f
14. t
15. f
16. f
17. e
18. a
19. b
20. e
21. d
22. c
23. e
24. e
25. e
26. e
27. b
28. d
29. d
30. a

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VIII: FRONT SUSPENSION SYSTEM DESIGNS

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the components and operating principles of various types of front suspension systems. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions related to front suspension systems (Competencies S1-S6, Unit VIII Test).

II. Identify the basic components and design of a suspension system (Competencies S1-S6, Unit VIII Test).

Lesson 2. I. Identify the characteristics of an SLA suspension (Competencies S1-S4, Unit VIII Test).

II. Identify the characteristics of a conventional MacPherson strut front suspension (Competencies S5 and S6, Unit VIII Test).

III. Identify the characteristics of a modified MacPherson strut suspension (Competencies S5 and S6, Unit VIII Test).

IV. Identify the characteristics of a straight axle front suspension (Competencies S1-S4, Unit VIII Test).

V. Identify the characteristics of a four-wheel-drive front axle suspension (Competencies S1-S4, Unit VIII Test).

VI. Identify the characteristics of a twin I-beam front suspension (Competencies S1-S4, Unit VIII Test).

Lesson 3. I. Identify the characteristics of tapered wheel bearings (Competencies S1-S3, Unit VIII Test).

II. Identify the characteristics of double row ball or roller bearings (Competencies S1-S3, Unit VIII Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material that is preliminary to ASE tasks appears in this unit; therefore, no ASE tasks are covered directly.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VIII: FRONT SUSPENSION SYSTEM DESIGNS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: SUSPENSION SYSTEM PARTS
    a. Information outline
    b. Assignment sheet
      AS1-L1-UVIII: Suspension System Components
  2. Lesson 2: TYPES OF FRONT SUSPENSION SYSTEMS
    a. Information outline
    b. Assignment sheet
      AS1-L2-UVIII: Types of Steering Systems
  3. Lesson 3: THE DESIGN AND FUNCTION OF WHEEL BEARINGS
    a. Information outline
    b. Assignment sheet
      AS1-L3-UVIII: Wheel Bearings

E. Unit test

F. Answers to unit test

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do all assignment sheets before taking the Unit VIII test.

B. Suggested audio-visual material from the Media Center, State Fair Community College, Sedalia, Mo.

   1. Steering and Suspension--Front-End Type (AM-83-270), 1983.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VIII: FRONT SUSPENSION SYSTEM DESIGNS

LESSON 1: SUSPENSION SYSTEM PARTS

I. Terms and definitions

A. Aeration--Air mixing with hydraulic fluid, causing the fluid to foam.

B. Ball joint--A suspension component that connects the control arm to the steering knuckle. The ball joint has the ability to tilt and rotate.

C. Control arm--A suspension component that links the vehicle wheels to the frame, thus allowing for suspension movement. Control arms are also referred to as "A" arms or wishbones because of their shape.

D. Coil spring--A suspension spring that consists of a spring steel bar wound into a coil.

E. Independent suspension--Front or rear suspension in which those wheels that are positioned opposite to each other on the axle move up and down independently of each other.

F. Jounce--The upward movement of the wheel and suspension system.

G. Kingpin--A hardened steel pin that passes through the outer end of the axle and the steering knuckle. The kingpin allows the steering knuckle to pivot on the axle. The kingpin is also referred to as a spindle bolt.

H. Leaf spring--The suspension spring is constructed of either a leaf or leaves made of flat spring steel.

I. MacPherson strut--The type of independent suspension in which a coil spring and shock absorber combination is used in place of an upper control arm.

J. Rebound--The downward movement of the wheel and suspension.

K. Ride height--The distance from a specific point on a vehicle to the road surface.

L. Shock absorber--A hydraulic device used to dampen spring movement (oscillations) in a suspension system. The shock absorber is also referred to as a shock.

M. Spindle--A component that extends outward from the steering knuckle. The spindle supports the wheel bearings and may or may not be integral with the knuckle.

N. Sprung weight--Vehicle weight that is supported by suspension springs.

O. Stabilizer bar (also called sway or anti-sway bar)--A suspension-control component used to minimize a vehicle's swaying and leaning during turns.

P. Steering knuckle--A component that is supported by and pivots on either upper and lower ball joints or a kingpin. The steering knuckle may be either integral with the spindle or bolted to it.

Q. Straight axle--A non-independent suspension axle. On a straight axle, movement of one wheel directly affects the opposite wheel.

R. Strut rod--A steel rod positioned between the frame and the lower control arm. The strut rod stabilizes the lower control arm.

S. Torsion bar spring--A suspension spring consisting of a round spring steel bar. One end of the torsion bar spring is attached to the lower control arm while the other end is attached to the vehicle's frame.

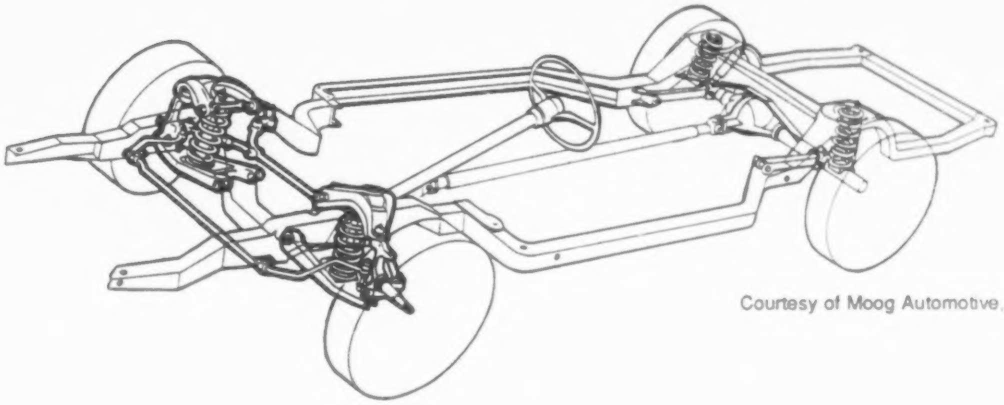
T. Twin I-beam axle--A suspension system that uses two axles shaped like an I-beam. One of the axles is connected to each wheel, thus allowing for independent suspension action.

U. Unsprung weight--Vehicle weight that is not supported by the suspension springs. Unsprung weight includes such items as wheels and tires.

II. Basic components and design of a suspension system

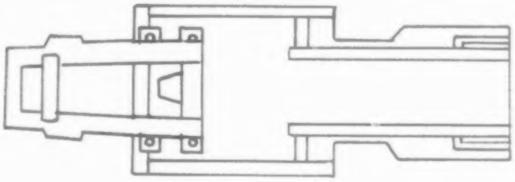
A. The vehicle's frame is the foundation upon which the entire vehicle is constructed. Most vehicles use either a conventional frame (also called a full frame) or a unibody frame.

1. A conventional frame (or full frame) is a sturdy steel frame to which the vehicle's body parts and all other major components are directly or indirectly attached. The frame provides the strength and rigidity required to keep the vehicle intact.



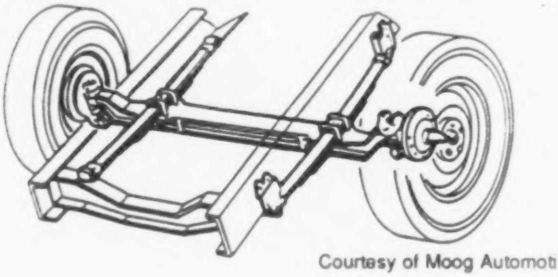
Courtesy of Moog Automotive, Inc.

2. A unibody frame has no separate frame structure. The vehicle body is designed so that the body parts themselves supply the strength and rigidity required to keep the vehicle intact.



B. Straight axle and independent front suspension suspensions

1. Most early passenger cars used a straight axle design. A major disadvantage of this design is that when one wheel is raised or lowered (as might occur when the vehicle hits a bump or pothole), the alignment of the opposite wheel is temporarily thrown off. On the other hand, the straight axle can support a great deal of weight and is, therefore, still used on large trucks and some four-wheel-drive vehicles.



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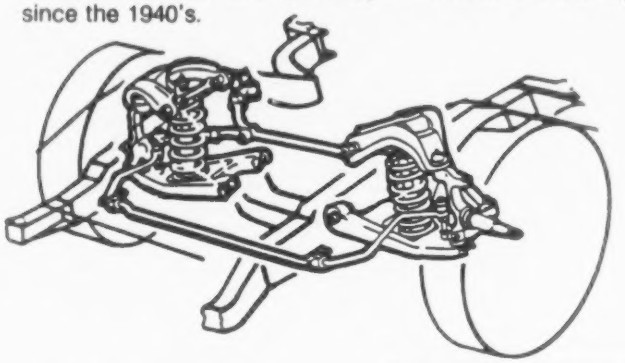
2. Independent front suspension allows each wheel to compensate for changes in the road surface without greatly affecting the other wheel at the same end of the vehicle. Independent front suspension, therefore, improves vehicle handling and increases tire life. Most passenger cars have used independent front suspension since the 1940's.



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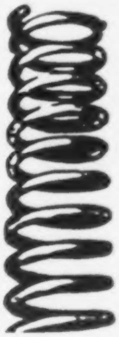
C. The springs in the suspension system absorb shocks and maintain the correct vehicle ride height. There are three basic types of suspension springs: coil springs, leaf springs, and torsion bar springs. A fourth type of springs, called air springs, is used on a few vehicles; air springs will be discussed later.

1. Coil springs

a. Coil springs are often used in today's passenger cars. The coil spring is made from a round spring steel bar stock, which is wound into the shape of a coil. The coil spring compresses to absorb a road shock and then rebounds to its original position, thus maintaining the proper ride height of the vehicle.

b. On conventional front suspension systems, the spring is usually mounted between the frame and the lower control arm. Some front suspension designs, however, have the spring located between the spring tower and the upper control arm. Rubber insulators, positioned between the spring and its mounting surface, reduce suspension noise.



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2. Leaf springs

a. Leaf springs are used on solid axle rear suspensions and on front suspensions that use the straight axle design. These springs are commonly made from flat spring steel, which is shaped like an arch.

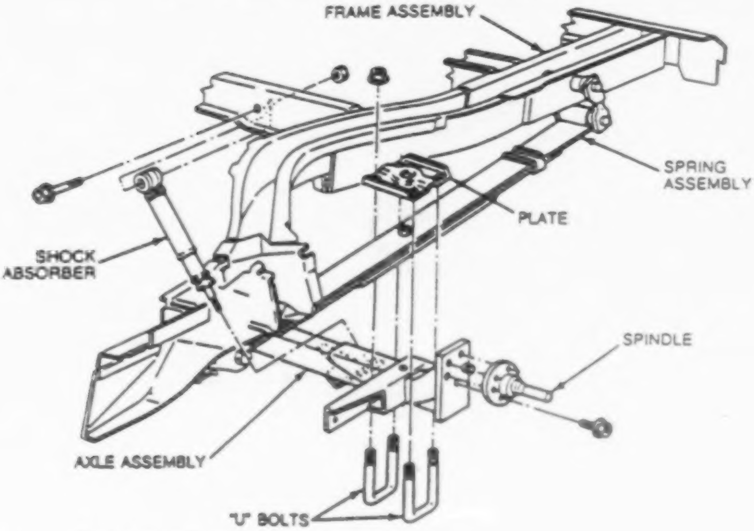
b. The main leaf of the leaf spring has a loop or eye machined into each end. A rubber bushing is inserted into each eye; by way of this bushing, the leaf is attached to the vehicle's frame. The rear of the spring is attached to the frame via a shackle assembly that permits the spring to lengthen or shorten according to the forces of acceleration and braking.

c. Additional leaves are added to the spring to achieve the desired stiffness and load-carrying capacity. (Each additional leaf is usually shorter than the one added previously.) The leaves are held in place by a tie bolt inserted through the center of the leaves and by rebound clips on the leaves' ends. The leaf spring is usually mounted at a right angle to the axle and is attached to the axle by U-bolts.

d. In multiple leaf springs, the leaves are usually separated by rubber, plastic, or zinc spacers called interleaves. The interleaves reduce any noise and wear that may result from the spring leaves working against each other.

e. A monoleaf spring consists of only one leaf. These springs are generally thick in the center and tapered down on each end. These leaf springs provide lighter vehicles with a smooth ride and greater load-carrying capability.

(NOTE: In order to achieve a lower vehicle weight, some leaf springs use a single leaf spring made of fiberglass.)



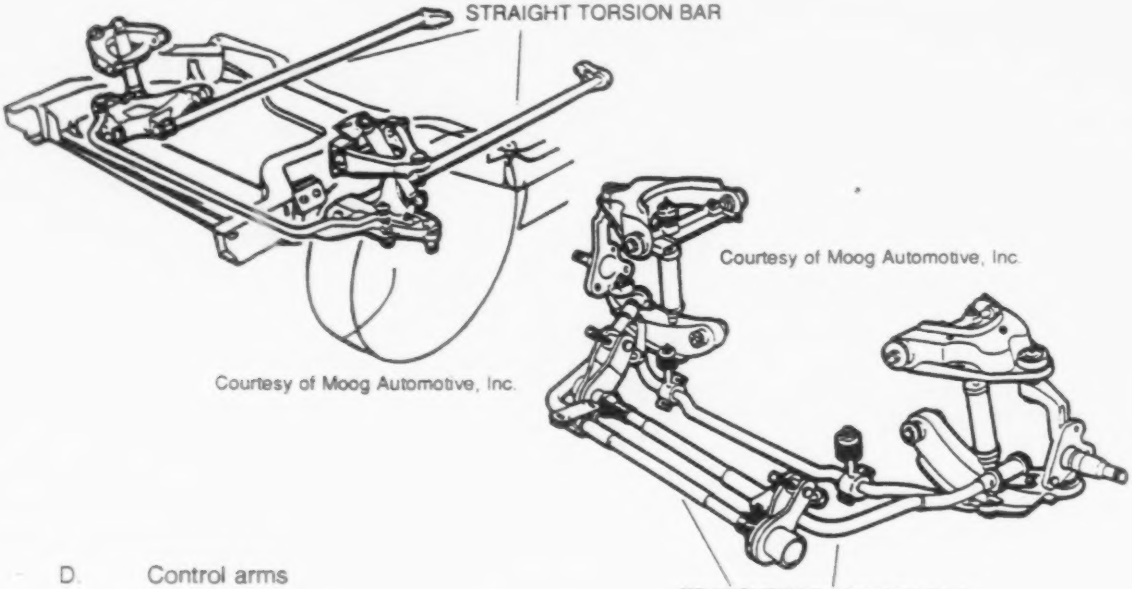
3. Torsion bar springs

a. A torsion bar spring is a long spring steel shaft. One end of the shaft is attached to the lower control arm while the other end is attached to the vehicle's frame.

b. When a wheel hits a bump in the road, the control arm moves, causing the torsion bar to twist and thus absorb the shock. After the shock is absorbed, the bar returns to its original position, thus returning the vehicle to its proper ride height.

(NOTE: Torsion bars can be adjusted to control the ride height of the vehicle.)

c. There are two basic designs of torsion bar springs: the straight type and the (cross) transverse type. Straight torsion bar springs are mounted to the frame behind the lower control arm and extend forward to the control arm. The (cross) transverse torsion bar springs are L-shaped and are mounted solidly to the frame on the front corner opposite to the wheel they serve. The springs run across the frame, parallel to the front frame crossmember, and then turn toward the rear of the vehicle and attach to the outer end of the lower crossmember in a rubber bushing.



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D. Control arms

1. Upper control arms

a. The upper control arms (a frames) are attached to the vehicle frame by way of bushings. The bushings allow the control arms to move up and down with the wheels. The control arm pivots on a steel shaft, which is bolted to the frame. (The control arm pivots in the shaft in either steel-clad rubber or threaded-steel bushings.)

b. The outer end of the control arm is attached to the steering knuckle via a ball joint. Attached to the control arms or vehicle frame are heavy rubber rebound bumpers. The rebound bumpers absorb the shock when suspension springs are compressed or extended to the point at which the control arms contact the frame.

c. On many vehicles, a provision for adjusting the wheel alignment is provided at the point where the upper control arm shaft connects to the vehicle.

2. Lower control arms

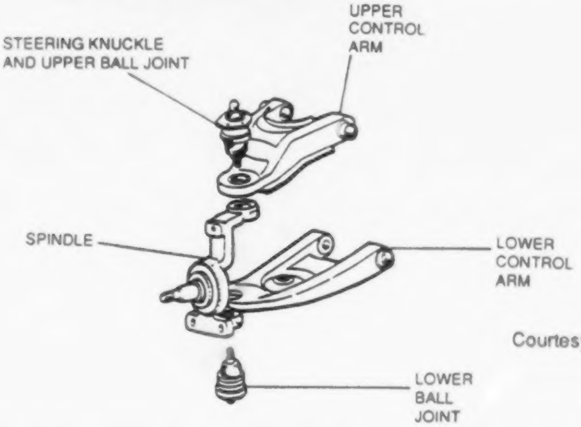
a. The double bushing lower control arm (a frame) uses two bushings and two mounting points to connect the control arm to the frame. The double bushings and mounting points provide extra stability.

b. The single bushing lower control arm takes up less space than the double bushing arm but is more susceptible to movement. To control the extra movement, strut rods are usually added to the suspension system.

c. The lower control arm is usually bolted to the vehicle frame with a steel-clad rubber pivot bushing and bolt arrangement. The outer end of the lower control arm is attached to the steering knuckle by a ball joint.

d. The coil spring or torsion bar spring is usually attached to the lower control arm; however, some designs have the coil spring resting on the upper control arm.

e. In most modern independent front suspensions, the upper control arm is shorter than the lower control arm. This type of suspension is often referred to as short and long arm (SLA) suspension. SLA suspension allows for longer tire life than earlier systems in which both control arms are of the same length.



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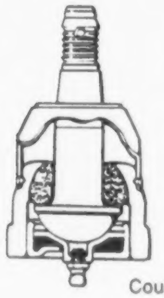
E. Jounce rebound bumpers are solid rubber cushions that limit suspension travel and absorb the shock of suspension and frame contact. Jounce rebound bumpers are fastened to the control arms or the frame.

F. Ball joints

1. Ball joints are used to connect the steering knuckle to the outer end of the control arms. The joints allow the steering knuckle to turn between the control arms as the steering wheel is turned. The ball joints are attached to the steering knuckle via a tapered stud and nut arrangement or a straight stud with a notch and a pinch bolt.



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2. Ball joints are similar in design to the ball sockets found in tie rod ends and other steering linkage joints. Ball joints are heavier than ball sockets, however. There are two basic types of ball joints: load-carrying and nonload-carrying.

   a. Load-carrying joints support the weight of the vehicle. They are mounted on the outer control arm ends to which the coil springs are seated or to which the torsion bar springs are attached.

   b. Nonload-carrying joints contain a built-in preload. A spring maintains tension on the joint at all times and compensates for wear. The design of nonload-carrying joints helps to dampen vibration and road shock.

      (NOTE: Nonload-carrying ball joints are also referred to as roller ball joints.)

G. Conventional shock absorbers

1. Conventional shock absorbers control or dampen suspension spring movement in both directions. Without shock absorbers, spring movement or oscillations (such as might result from hitting a bump) would continue until all energy was expelled from the spring. The result would be a very rough ride, which might result in loss of vehicle control.

2. Shock absorbers use hydraulic resistance to control spring oscillations. The shock absorber achieves this resistance by forcing fluid through metered, internal passages.

   (NOTE: Conventional shock absorbers do not control a vehicle's ride height. Ride height is controlled by the springs. Air adjustable shock absorbers do, however, affect vehicle ride height; these shock absorbers will be discussed in a later unit.)

3. Shock absorber construction

   a. The shock absorber consists of a piston and rod assembly, which operates within an inner steel tube (cylinder). The upper end of the cylinder is sealed by a piston rod seal; the lower end is sealed by a base compression valve assembly. The cylinder is completely filled with oil at all times. Surrounding the inner tube is an outer tube, which provides space for reserve fluid and overflow for the pressure tube.

   b. A rubber mounting bushing connects the piston rod to the vehicle frame. A lower mounting bushing connects the pressure and reservoir tubes to the suspension.

4. Operation of the shock absorber

a. As the wheel moves up and down, the suspension spring compresses (jounce) and extends (rebound). This movement of the suspension spring, in turn, compresses or extends the shock absorber, thus pushing the shock absorber piston through a column of oil within the pressure tube.

b. The piston contains metered orifices, which allow fluid to flow at a specific rate. Because fluid cannot be compressed, the size of the orifices determines the shock's effectiveness.

c. In addition, when the shock is compressed, fluid is forced through the compression base valve into the reservoir tube.

d. The faster the piston is pushed, the greater the pressure build-up below the piston and the greater the dampening force.

e. As the suspension rebounds, the piston is pulled up through the fluid above it. As the rebound speed increases, a blow-off disc opens to allow fluid to pass at a faster rate, thus making the vehicle ride more smoothly.

H. Gas-charged shock absorbers

1. During rapid jounce and rebound, the fluid in conventional shock absorbers tends to become aerated. Aeration causes the shock absorber to skip or become mushy. Like conventional shocks, gas-charged shocks also operate on the principle of hydraulic fluid displacement; gas-charged shocks, however, are not susceptible to aeration.

2. Design of the gas-charged shock

a. One common type of gas-charged shock uses a piston and oil chamber much like those found in conventional shocks; instead of a reserve tube, however, the gas-charged shocks incorporate a floating dividing piston that separates the oil chamber from the gas chamber.

b. The gas chamber contains nitrogen gas at a pressure of approximately 100 to 360 psi. As the main shock absorber piston moves up and down in the tube, the dividing piston and the gas chamber below it compensate for the difference in fluid volume, thus preventing the fluid from becoming aerated.

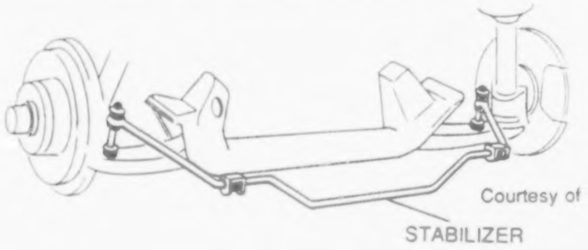
(NOTE: There are two classes of gas filled shocks: high pressure and low pressure. Most passenger vehicles use low pressure type gas shocks.)

I. A spring-assist shock absorber is a conventional shock absorber with a coil spring fitted around the outside of the shock. Spring-assist shocks allow the vehicle to carry greater loads.

J. The stabilizer bar (also called an anti-sway bar or sway bar)

1 The stabilizer bar can be added to a vehicle to improve the suspension's stability. A stabilizer bar consists of a "U-shaped" spring steel bar. Each end of the stabilizer bar is attached to a lower control arm via rubber mounts or links. The center portion of the "U" attaches to the vehicle's frame through rubber mounts.

2. When one of the vehicle's wheels is raised or lowered, the stabilizer bar begins to twist, applying force to the opposite control arm and thus keeping the vehicle in a more level position. The stabilizer bar thus reduces swaying and leaning of the vehicle's body and improves handling during cornering.



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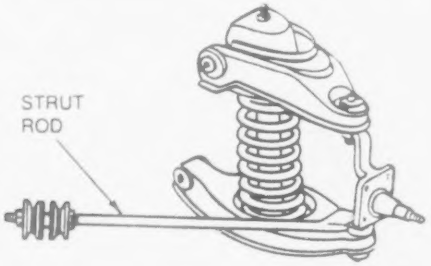
K. Strut rods are used to control movement of the lower control arm. Strut rods are more commonly found on suspension designs that use a single bushing lower control arm. The strut rod is bolted directly to the lower control arm and is attached to the vehicle's frame through rubber mounting bushings. Some designs have the sway bar double as strut rods.



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L. The wheel spindle assembly consists of the wheel spindle and the steering knuckle. The wheel spindle connects to the wheel through the wheel hub and bearings, which ride on the spindle. The steering knuckle is located in the inner portion of the spindle assembly and connects to the control arm through the ball joints. In some vehicles, spindle and steering knuckles consist of separate pieces bolted together; in other vehicles, spindle and steering knuckles are forged as a single unit.

MODULE: STEERING AND SUSPENSION SYSTEMS

SUSPENSION SYSTEM COMPONENTS

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. What is the major function of the suspension springs?

2. List the three types of suspension springs.

3. How are the control arms attached to the steering knuckles?

4. What suspension components are used to dampen spring oscillations?

5. What type of shock absorbers are not susceptible to fluid aeration?

6. What suspension component is used to prevent body sway?

MODULE: STEERING AND SUSPENSION SYSTEMS

SUSPENSION SYSTEM COMPONENTS

(ANSWER SHEET)

1. The major function of suspension springs is to absorb shocks.
2. Leaf, coil, and torsion bar
3. The control arms are attached to the steering knuckles via ball joints.
4. Shock absorbers
5. Gas-charged shock absorbers
6. A sway bar

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VIII: FRONT SUSPENSION SYSTEM DESIGNS

LESSON 2: TYPES OF FRONT SUSPENSION SYSTEMS

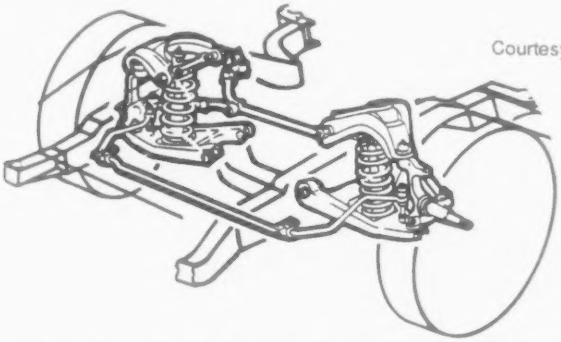
I. Conventional short and long arm suspension (referred to as SLA suspension) is an independent front suspension used on many American vehicles.

   A. In SLA suspensions, an upper and lower control arm is located at each front wheel. The control arms are attached to the steering knuckle via upper and lower ball joints and to the frame via bushings.

   B. The SLA suspension uses a coil or torsion bar spring to absorb shocks and maintain the correct ride height of the vehicle.

   C. Most SLA designs have the coil springs resting on the lower control arm and are referred to as coil under suspensions. In these designs, the load-carrying ball joint is on the lower control arm. The ball joint on the upper control arm is the nonload-carrying ball joint. A shock absorber is mounted between the vehicle's frame and lower control arm.

   (NOTE: The SLA suspension system normally uses a stabilizer bar.)



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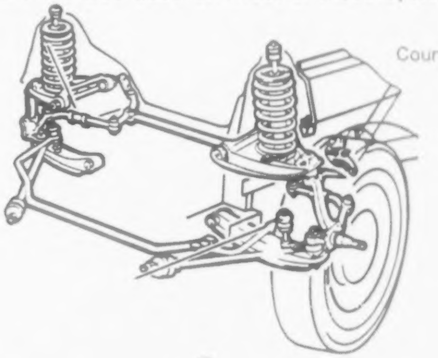
   D. Some SLA designs have the coil spring resting on the upper control arm and are referred to as coil over suspensions. These designs require a spring tower, which is a special frame extension located above the coil spring. The upper end of the spring is seated on the spring tower. Also in these designs, the upper ball joint is the load-carrying joint and the lower ball joint is the nonload-carrying joint. A shock absorber is mounted between the spring tower and upper control arm. The lower control arm usually pivots on a single bushing, thus requiring a strut to stabilize the arm.

   (NOTE: Stabilizer bars are also used on most of these systems.)



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II. Conventional MacPherson strut front suspension

A. Conventional MacPherson strut front suspension incorporates a shock absorber and a coil spring into a single unit. The MacPherson strut suspension is lighter and smaller than a conventional independent suspension and, therefore, is used quite frequently on today's vehicles. The unit is mounted between the steering knuckle and the vehicle's inner fender.

B. Design of the conventional MacPherson strut suspension

1. In some conventional MacPherson strut suspensions, the steering knuckle/spindle is permanently attached to the lower end of the strut assembly, while in others the lower end of the strut tube is bolted to the steering knuckle.

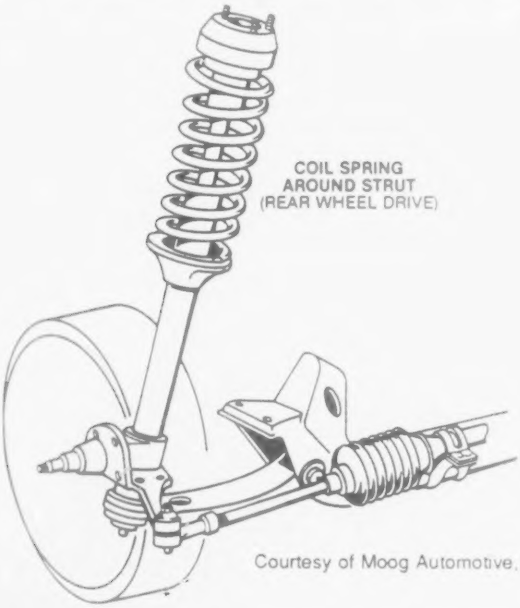
2. The upper end of the shock absorber (strut) piston rod attaches to a reinforced vehicle inner fender (the attachment is made via an upper mount, which is bolted to the fender). A rubber mounted bushing or bearing arrangement, located at the top mount, cushions the shock and allows the strut to turn with the wheel as it is steered.

3. A lower control arm is connected to the lower end of the steering knuckle via a ball joint. No upper control arm or upper ball joint is used with this design.

4. The shock absorber (dampener) fits inside the strut tube; the piston rod extends out of the top. Some MacPherson strut units allow a worn shock absorber (dampener) to be replaced. Other units require that the entire strut assembly be replaced if the shock absorber is worn.

5. The coil spring is serviced separately from the strut. The spring rests on a lower spring seat, which is welded to the strut tube. The upper end of the spring is retained by an upper spring seat, which either fits under or is integral with the upper strut mount. The spring is held in place on the strut assembly by a retaining nut on the piston shaft.

6. A stabilizer bar and strut rods are normally used with MacPherson struts.



Courtesy of Moog Automotive, Inc.

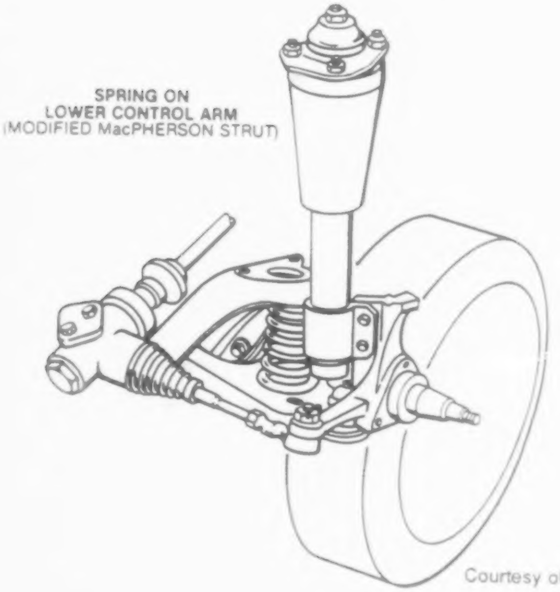
III. Modified MacPherson strut suspension

A. The modified MacPherson strut suspension system blends the SLA and the conventional MacPherson strut designs.

B. Design of the modified MacPherson strut suspension

1. A spring and lower control arm arrangement similar to those in a short and long arm suspension is used.

2. A strut assembly is used in place of an upper control arm and ball joint. No spring is attached to the strut. In addition to taking the place of the upper control arm, the strut acts as the shock absorber.



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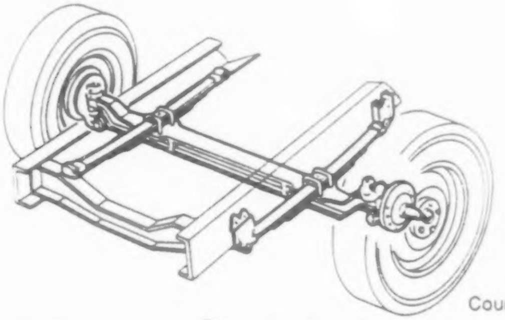
IV. Straight axle front suspension

A. Straight axle front suspensions are usually found only on large trucks.

B. Design of the straight axle front suspension

1. In straight axle front suspension, each end of a solid forged steel beam axle is connected to leaf springs via U-bolts. A spring hanger bracket connects the front of the spring to the frame via a rubber bushing in the spring eye. A shackle connects the rear of the spring to the frame. The shackle allows the spring to change its length as it flexes.



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2. Special hardened steel pins, called kingpins, connect the steering knuckles to each end of the axle. The kingpins are pressed into the axle; the steering knuckles pivot on the kingpin in bushings.

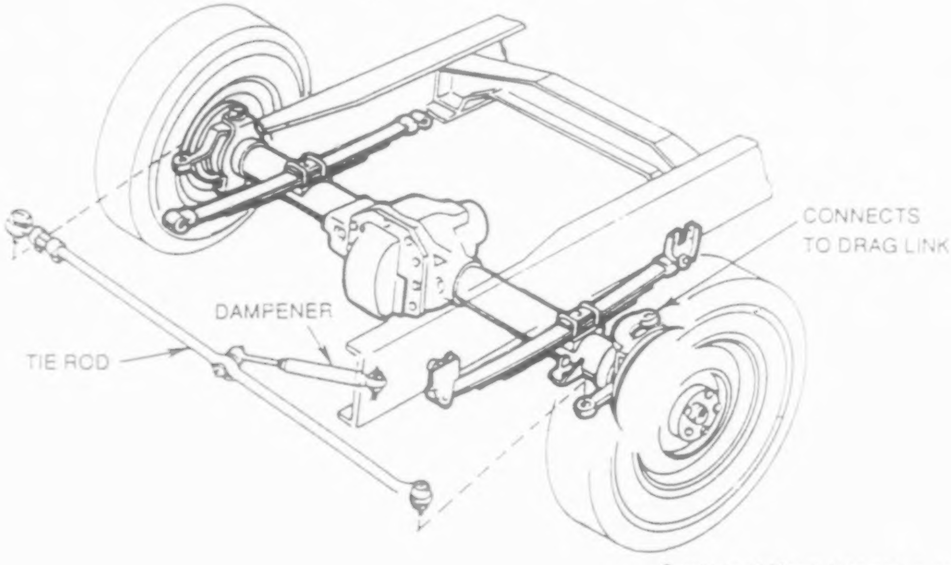
3. Thrust bearings, inserted between the axle and spindle, support the vehicle load. A shock absorber is connected to the vehicle's frame and to each end of the axle

V. Four-wheel-drive front axle suspension

A. The four-wheel-drive front axle suspension is widely used in today's four-wheel-drive vehicles.

B. Design of the four-wheel-drive front axle suspension

1. The four-wheel-drive front axle suspension is similar to the straight axle front suspension. In place of the solid beam axle, however, a solid drive axle housing is used.



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2. The four-wheel-drive front axle uses either leaf or coil springs.

    a. The leaf spring connections are similar to those in a straight axle.

    b. When coil springs are used, special arms--called radius arms--maintain the position of the axle assembly. The radius arms are mounted on the vehicle frame via special rubber bushings. The arms extend forward and are connected to the outer ends of the axle housing.

3. The steering knuckles are usually attached to and pivot on the axle housing via the upper and lower ball joints.

4. Shock absorbers are mounted between the vehicle's frame and the axle housing.

VI. Twin I-beam front suspension

A. The twin I-beam front suspension system combines the strength of a straight axle design with the ride and handling benefits of an independent suspension.

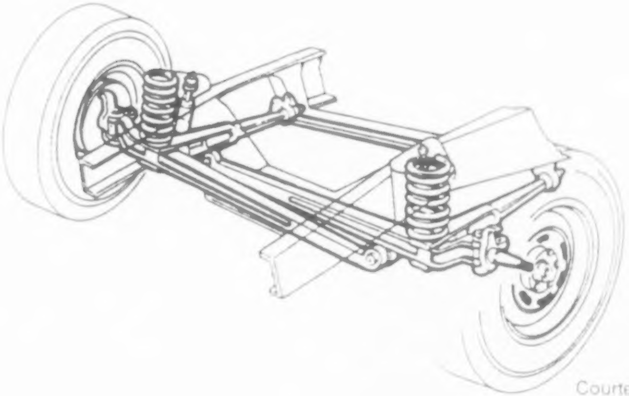
B. The twin I-beam front suspension uses two forged I-beam axles. One end of each axle is attached to one spindle and a radius arm. The other end of each axle is connected to the frame via a pivot bushing and bolt.

C. Each steering knuckle is attached to the axle through a kingpin. The kingpin is installed in the steering knuckle via bushings and is pressed into the end of the axle. A thrust bearing between the axle and the spindle supports the load on the axle.

D. Radius arms are used to control the forward and backward movement of the axles. The arms are mounted from the outer end of each axle rearward to the vehicle frame. Rubber bushings are located at the frame mounting points. The radius arms allow for the up and down movement of the suspension.

E. Coil springs are mounted between spring pockets on the vehicle's frame and axle.

F. Shock absorbers are used at each wheel to dampen spring movement.



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MODULE: STEERING AND SUSPENSION SYSTEMS

TYPES OF SUSPENSION SYSTEMS

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. An independent front suspension that uses an upper and lower control arm is called what?

2. If the spring is positioned on the lower control arm, which ball joint carries the load?

3. MacPherson strut front suspensions use how many control arms per wheel?

4. In a modified MacPherson strut front suspension, what component rests on the lower control arm?

5. What device is used to connect a straight axle to the steering knuckles?

6. What component fits inside the strut tube of a MacPherson strut unit?

MODULE: STEERING AND SUSPENSION SYSTEMS

TYPES OF SUSPENSION SYSTEMS

(ANSWER SHEET)

1. Short and long arm suspension (SLA)
2. Lower ball joint
3. One
4. The spring
5. Kingpins
6. The shock absorber

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VIII: FRONT SUSPENSION SYSTEM DESIGNS

LESSON 3: THE DESIGN AND FUNCTION OF WHEEL BEARINGS

I. Tapered wheel bearings

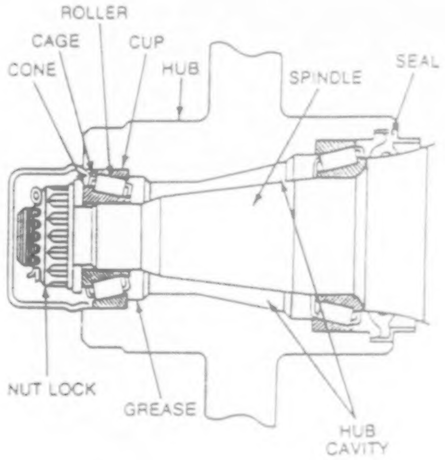
A. Wheel bearings are used at each wheel hub to minimize rolling resistance and to allow the wheels to rotate freely. On rear-wheel-drive vehicles, the most commonly used front-wheel bearing is the tapered roller bearing. The tapered roller wheel bearing design is also used on the rear wheels of many front-wheel-drive vehicles. The tapered roller bearing is favored because of its load-carrying ability.

B. Design of the tapered roller wheel bearings

1. The typical rear-wheel-drive vehicle has dual tapered roller bearings mounted on a stationary spindle at each wheel. The outer wheel bearing is normally smaller than the inner one. The bearings are positioned so that the tapers face each other; this positioning holds the wheel hub in lateral alignment.

2. Tapered roller bearings consist of an outer cone (also called a race), an inner cone, a cage (also called a separator), and the tapered rollers. All bearing surfaces are very hard. The rollers roll on the flat surfaces of the inner and outer cones. The bearing cage (made of steel or plastic) maintains the proper spacing between the rollers. The outer cones are pressed into the hub. The bearing cage also holds the tapered rollers against the inner cone.

(NOTE: Ball bearings, which are similar in design to tapered bearings, are used on some vehicles. These are generally found on older model vehicles.)



3. Spindle construction

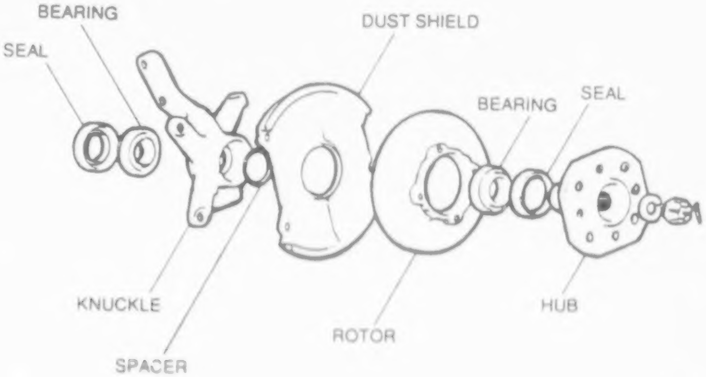
a. A hex nut is threaded onto the spindle to retain the bearings and maintain their proper adjustment. A cotter pin locks the nut in place.

b. The outer end of the spindle is slotted, which allows it to accept a special tabbed washer. The washer keeps the spinning motion of the bearing from being transferred to the retaining nut. The washer is installed over the spindle before the nut is installed.

c. The spindle connects to the wheel via the wheel hub and bearings, which ride on the spindle. The spindle is either connected to or integral with the steering knuckle.

d. High-temperature wheel bearing grease, packed between the bearings and hub, provides lubrication.

C. A somewhat modified version of the tapered roller bearing design is used on the front wheels of some front-wheel-drive vehicles. In the modified design, a selective spacer placed between the bearings allows for their adjustment.

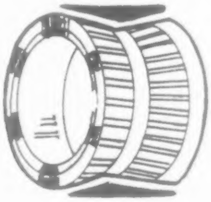


D. When the tapered bearings are used on front-wheel-drive vehicles, the outer bearing races are pressed into the steering knuckle and the wheel hub is pressed into the inner races.

II. Double row ball or roller bearings

A. A type of wheel bearing that is used quite extensively on both the front and rear wheels of today's front-wheel-drive vehicles is the double row ball or roller bearing.

B. The double row ball or roller bearing has inner and outer races with two parallel grooves in which two rows of balls or rollers roll. The bearing is nonadjustable and permanently lubricated and sealed. On some vehicles, the bearing is integral with the wheel hub. A bearing and a hub that are integral must be serviced as a complete unit.



MODULE: STEERING AND SUSPENSION SYSTEMS

WHEEL BEARINGS

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. What type of wheel bearing is most commonly used on rear-wheel-drive vehicles?

2. List the four major parts of a tapered roller wheel bearing.

3. The outer wheel bearing cones are pressed into what component?

4. The wheel bearings are supported by what component?

5. Many of today's front-wheel-drive vehicles use what kind of tapered roller or ball bearings?

MODULE: STEERING AND SUSPENSION SYSTEMS

WHEEL BEARINGS

(ANSWER SHEET)

1. Tapered roller bearing
2. Inner cone, outer cone, rollers, cage
3. Hub
4. Spindle
5. Double row tapered roller or ball bearings

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT VIII: FRONT SUSPENSION SYSTEM DESIGNS

UNIT VIII TEST

SECTION A. Match the terms below with their appropriate definitions.

____ 1. A suspension component that dampens spring movement.

____ 2. A suspension component that supports the wheel bearings.

____ 3. A suspension component that controls swaying and leaning of the vehicle.

____ 4. A non-independent suspension.

____ 5. A spring steel bar attached to the control arm and the frame.

____ 6. A suspension component that is supported by and pivots on either upper and lower ball joints or a kingpin.

____ 7. The downward movement of the wheel and suspension.

____ 8. An independent suspension system in which the spring and shock are combined.

____ 9. The upward movement of the wheel and suspension.

____ 10. A suspension spring made of wound spring steel.

____ 11. A suspension component that tilts and rotates.

____ 12. A suspension component that links the wheel to the frame.

a. Stabilizer bar
b. Ball joint
c. Control arm
d. Unsprung weight
e. Straight axle
ab. Twin I-beam axle
ac. MacPherson strut suspension
ad. Jounce
ae. Rebound
bc. Coil spring
bd. Torsion bar spring
be. Shock absorber
cd. Steering knuckle
ce. Spindle

SECTION B. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 13. The suspension is the foundation upon which a vehicle is constructed.

____ 14. Most modern automobiles use either conventional or unibody frames.

____ 15. The straight front axle suspension improves vehicle handling and increases tire life.

____ 16. An independent front suspension allows wheels on the same axle to move up and down independently of each other.

____ 17. Straight front axles are used on many front-wheel-drive vehicles.

____ 18. The main function of shock absorbers is to absorb shocks.

____ 19. Most late-model automobiles use either coil, leaf, or torsion bar springs.

____ 20. Torsion bar springs are made of flat steel springs in the shape of an arch.

____ 21. Some types of leaf springs are not made of spring steel.

____ 22. Torsion bar springs can be adjusted to change a vehicle's ride height.

____ 23. Torsion bar springs are connected to the upper arm.

____ 24. The control arms are connected to the vehicle frame via bearings.

____ 25. The control arms are connected to the steering knuckle via ball joints.

____ 26. In most modern suspension designs, the lower control arm is smaller than the upper control arm.

____ 27. SLA stands for steering linkage arrangement.

____ 28. Ball joints are either standard or adjustable.

____ 29. Shock absorbers control ride height.

____ 30. Gas-charged shocks are not susceptible to aeration.

____ 31. Suspensions that use spring assisted shock absorbers can carry greater loads.

____ 32. Stabilizer bars reduce body sway during cornering.

____ 33. MacPherson strut suspensions commonly use two ball joints.

____ 34. In some vehicles, the spindle is integral with the steering knuckle.

____ 35. Ball joints are similar in design to ball sockets used on tie rod ends.

____ 36. On some vehicles, torsion bars are mounted transversely.

____ 37. Conventional SLA suspension systems use ball joints and control arms.

____ 38. Suspension systems that have the coil spring resting on the upper control arm use a spring tower.

____ 39. Solid axle front suspensions use either leaf or coil springs.

____ 40. On four-wheel-drive front axles, the steering knuckles are mounted between the ball joints.

____ 41. Wheel bearing lubrication is provided by grease packed into the bearing.

____ 42. Tapered ball bearings are sealed and nonadjustable.

SECTION C. Select the best answer from the five choices listed.

____ 43. On conventional front suspensions, the coil spring is usually located

a. between the frame and lower control arm.
b. between the frame and the upper control arm.
c. on the upper control arm.
d. on the strut.
e. in none of the above positions.

____ 44. MacPherson strut suspensions are used extensively in today's vehicles because the strut

a. can be mounted between the inner fender and the steering knuckle.
b. incorporates a shock absorber and a coil spring in one unit.
c. is integral with the steering knuckle.
d. is integral with the coil springs.
e. is relatively small and light.

____ 45. In MacPherson struts, the shock is

a. contained within the strut tube.
b. mounted to the upper control arm.
c. connected to the coil spring.
d. mounted to the load-carrying ball joint.
e. integral with the frame.

____ 46. The modified MacPherson strut suspension combines the MacPherson strut and

a. the SLA suspension.
b. straight axle suspension.
c. conventional shock absorbers.
d. leaf springs and torsion bars.
e. none of the above.

____ 47. The most common type of front-wheel bearings used on today's rear-wheel-drive vehicles are

a. ball bearings.
b. tapered ball bearings.
c. roller bearings.
d. double row tapered roller bearings.
e. none of the above.

____ 48. When tapered roller wheel bearings are used on the front suspension of a rear-wheel-drive vehicle, which of the following statements is true?

a. Two bearings are mounted at each wheel.
b. The outer wheel bearing is smaller than the inner bearing.
c. The tapers face each other.
d. The races/cones are pressed into the hub.
e. All of the above are true.

____ 49. Threads on the spindle hold the

a. tire on the wheel.
b. wheel on the hub.
c. hub to the spindle.
d. bearings in proper adjustment.
e. nut lock in place.

____ 50. The parts of a tapered roller bearing include the

a. outer cone, inner cone, and cage.
b. outer cone, inner cone, and cage and rollers.
c. hub, separator, and inner and outer cones.
d. rollers, bearings, and separator.
e. spindle, hub, cone, and race and separator.

(NOTE: The student must obtain a minimum score of ____ on the Unit VIII Test in order to receive an evaluation for Competencies S1-S6.)

ANSWERS TO UNIT VIII TEST

1. be
2. ce
3. a
4. e
5. bd
6. cd
7. ae
8. ac
9. ad
10. bc
11. b
12. c
13. f
14. t
15. f
16. t
17. f
18. f
19. t
20. f
21. t
22. t
23. f
24. f
25. t
26. f
27. f
28. f
29. f
30. t
31. t
32. t
33. f
34. t
35. t
36. t
37. t
38. t
39. f
40. f
41. t
42. f
43. a
44. e
45. a
46. a
47. e
48. e
49. d
50. b

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IX: SLA SUSPENSION SYSTEM DIAGNOSIS AND LUBRICATION

UNIT OBJECTIVE

After completing this unit, the student should be able to measure vehicle ride height and determine necessary repairs, lubricate steering and suspension systems, and determine ball joint condition. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1. I. Identify the procedures for determining vehicle ride height (Competencies S1 and U2, Part I of the Unit IX Test).

II. Identify the procedures for inspecting load-carrying and nonload-carrying ball joints (Competencies S2 and S6, Parts II and III of the Unit IX Test).

III. Identify the procedures for lubricating a suspension and steering system (Competency S2, Part II of the Unit IX Test).

IV. Demonstrate the ability to:

  a. Measure vehicle ride height (Competencies S1, S5, and U2, JS1-L1-UIX).

  b. Test ball joints (Competencies S2 and S6, JS2-L1-UIX).

  c. Lubricate a steering and suspension system (Competencies S2 and S6, JS3-L1-UIX).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D029, D030, D034, D039, D042, and D054.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IX: SLA SUSPENSION SYSTEM DIAGNOSIS AND LUBRICATION

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plan

  1. Lesson 1: DIAGNOSING AND LUBRICATING AN SLA SUSPENSION SYSTEM

    a. Information outline

    b. Assignment sheets

      AS1-L1-UIX: Procedures for Measuring Vehicle Ride Height
      AS2-L1-UIX: Procedures for Inspecting Ball Joints

    c. Job sheets

      JS1-L1-UIX: Measuring Vehicle Ride Height
      JS2-L1-UIX: Testing Ball Joints
      JS3-L1-UIX: Lubricating a Steering and Suspension System

E. Unit test

F. Answers to unit test

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Chrysler Corporation. Service Manual, Rear Wheel Drive 1985 Passenger Cars. Chrysler Corporation. 1984.

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UIX in conjunction with JS1-L1-UIX and AS2-L1-UIX in conjunction with JS2-L1-UIX.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IX: SLA SUSPENSION SYSTEM DIAGNOSIS AND LUBRICATION

LESSON 1: DIAGNOSING AND LUBRICATING AN SLA SUSPENSION SYSTEM

I. Vehicle ride height (also called curb height or chassis height)

A. If the springs of a vehicle become weak or broken, the vehicle will sag. This sagging throws off the front end geometry of the vehicle, resulting in poor handling and excessive tire wear. By measuring vehicle ride height, the technician can determine if the springs or other parts of the suspension system are broken.

B. Procedure for measuring ride height

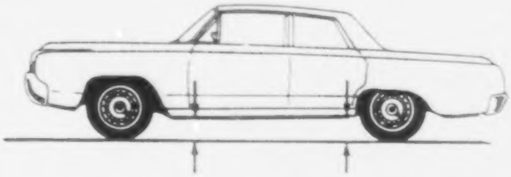
(NOTE: Service manuals give ride height specifications and identify the points on the vehicle at which measurements should be taken. Make sure the vehicle is on a level surface when taking measurements.)

1. Inflate tires to recommended pressure.
2. Make sure the vehicle's tires are of the correct size and type.
3. Fuel tank should be full.

   (NOTE: Add weight to the vehicle to compensate for a fuel tank that is less than full.)

4. The vehicle should contain no passengers, luggage, or other nonessential cargo.
5. Clean all foreign material from the area at which the measurement is to be taken.
6. Jounce the vehicle vigorously and allow the suspension to settle.
7. Measure the vehicle at all points identified in the service manual. Compare the measurements with specifications in the service manual.

C. Incorrect ride height can be caused by severe damage to the frame or other suspension components. If the vehicle has no such damage, improper ride height is probably a result of a problem with the springs. Defective coil springs must be replaced in pairs. Torsion bar springs can sometimes be adjusted to achieve the correct ride height.



Courtesy of Moog Automotive, Inc.

II. Inspecting ball joints (load-carrying and nonload-carrying) on SLA suspension systems

(NOTE: Nonload-carrying ball joints are also referred to as follower ball joints.)

(NOTE: Ball joints are inspected during alignment and routine suspension inspections.)

(NOTE: Under normal driving conditions the load-carrying ball joint is the joint which wears the fastest. However, always inspect both ball joints.)

A. Procedure for lifting a vehicle with SLA suspension to prepare for ball joint inspection

1. On coil under suspension systems, place the jack under the spring pocket of the lower control arm and lift the tire 2" off the ground.

2. On coil over suspension systems, place the jack under the frame cross member and lift the tire off the ground.

B. Procedure for inspecting the general condition of wear indicator and nonwear indicator ball joints (load-carrying)

1. Inspect the condition of the grease seal. Make sure the seal is not missing, torn, or split. A defective seal allows contaminants into the ball socket and will cause premature failure of the joint.

2. If the ball joint is drilled for a grease fitting or plug, make sure the fitting or plug is present. A missing fitting will cause the joint to fail.

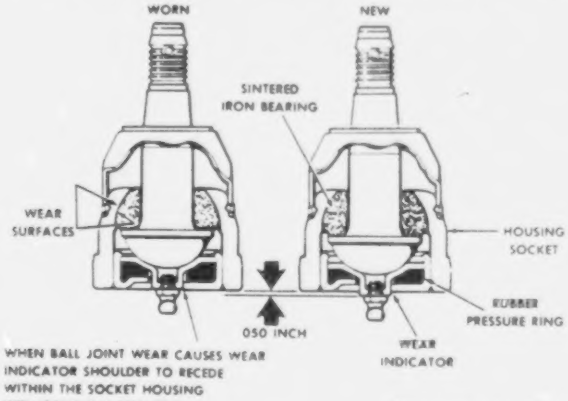
3. Make sure the castellated nut is tight on the tapered stud. Also make sure the cotter pin is installed correctly.

C. After inspecting the general condition of the load-carrying ball joint, the technician must determine if the joint is a wear indicator or a nonwear indicator before continuing the inspection. A wear indicator joint has a small shoulder protruding from the lower portion of the joint housing and can thus be distinguished from a nonwear indicator joint.

D. Procedure for inspecting a wear indicator ball joint (load-carrying)

1. The wear indicator joint should be inspected while it is loaded; therefore, make sure that the wheels support the car weight.

2. Examine the wear indicator ball joint carefully. If the joint's shoulder is flush with or completely receded into the housing, the joint is worn and should be replaced.


WORN
NEW
SINTERED IRON BEARING
WEAR SURFACES
HOUSING SOCKET
RUBBER PRESSURE RING
050 INCH
WEAR INDICATOR
WHEN BALL JOINT WEAR CAUSES WEAR INDICATOR SHOULDER TO RECEDE WITHIN THE SOCKET HOUSING REPLACEMENT IS REQUIRED

Courtesy of Moog Automotive, Inc.

E. Procedure for inspecting nonwear indicator ball joints (load-carrying)

1. Raise the vehicle and support it with jack stands to unload the ball joint.

   (NOTE: If the spring or torsion bar is on the lower control arm, place the jacks under the control arm as far outboard as possible. If the spring is on the upper control arm, place the jack stands under the frame.)

2. Following the procedure outlined below, check the joint for radial looseness.

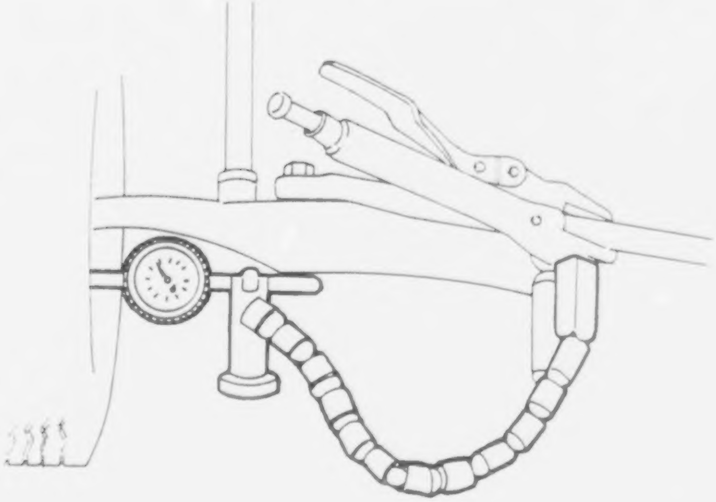
   (NOTE: Some ball joints should not be checked for radial looseness. Consult the appropriate service manual before performing the below procedure.)

   a. Mount the dial indicator on the vehicle. Make sure the dial plunger rests on the wheel rim that is nearest to the ball joint to be checked.

      (NOTE: Use a dial indicator that is equipped with a special flexible arm and a mounting bracket capable of reaching into tight locations.)

   b. After the joir [illegible] loaded, grasp the tire at the top and bottom and move it in and ou [illegible] erve the dial indicator reading.

   c. If the dial indicator reading exceeds manufacturer's specifications, move the tire in and out while an assistant observes the source of the looseness. Make sure the looseness is caused by the wheel bearing.

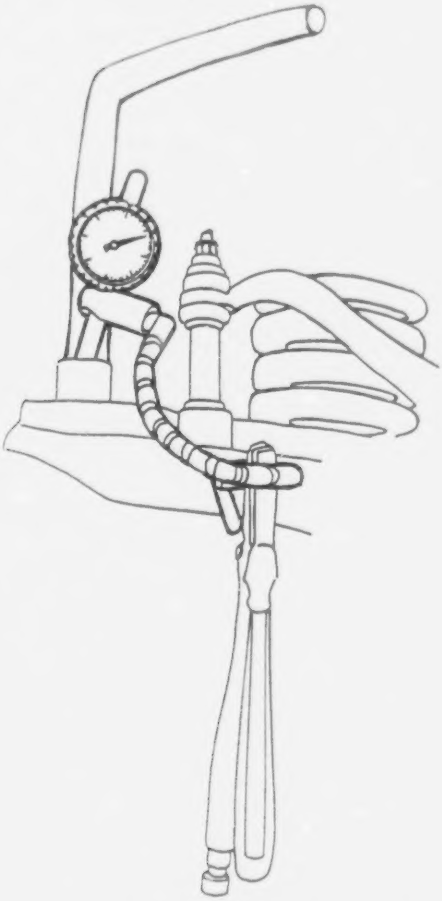


3. Following the procedure outlined below, check the ball joint for axial play.

   a. With the ball joint unloaded, clamp the dial indicator on the control arm. Place the plunger on the flat surface of the steering knuckle next to the ball joint stud. Clean dirt and grease from the part of the knuckle upon which the dial indicator will rest.

b. Insert a pry bar between the wheel and floor. Pry the wheel upward and note the dial indicator reading. Pry only hard enough to detect any play in the ball joint.

c. Compare the dial indicator reading to the manufacturer's specifications.



F. Procedure for inspecting the general condition of wear indicator and nonwear indicator ball joints (nonload-carrying)

1. Inspect the condition of the grease seal. Make sure the seal is not missing, torn, or split. A defective seal allows contaminants into the ball socket, resulting in premature failure of the joint.

2. If the ball joint is drilled for a grease fitting or plug, make sure the fitting or plug is present. A missing fitting will cause the joint to fail.

3. Make sure the castellated nut is tight on the tapered stud. Also make sure the cotter pin is installed correctly.

4. Make sure the ball joint is attached tightly to the control arm bolts or rivets.

G. Procedure for inspecting ball joints for looseness (nonload-carrying)

1. Place the dial indicator plunger against the edge of the wheel opposite the ball joint being checked.

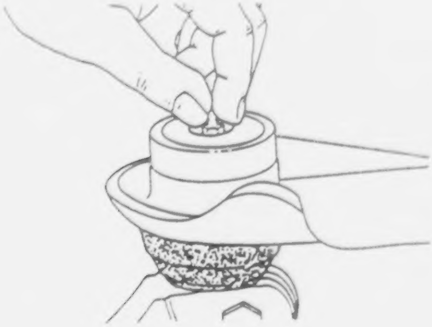
2. Grasp the tire and vigorously push and pull on it while watching the ball joint for movement.

3. Compare the reading on the dial indicator to the manufacturer's specifications.

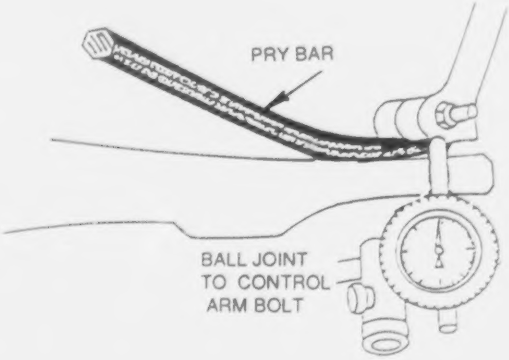
H. When inspecting ball joints on vehicles equipped with MacPherson struts, the technician can use the same procedures as listed above. Described in items "1" and "2" below, however, are two additional procedures for inspecting ball joints on some vehicles equipped with MacPherson struts.

(NOTE: Vehicles equipped with MacPherson struts use only load-carrying ball joints.)

1. With the weight of the vehicle resting on its tires, grasp the grease fitting and attempt to move it with the fingers. If the ball joint is worn, the grease fitting will move easily. If movement is noted, replace the ball joint.



2. Support the vehicle by the frame and allow the suspension to hang free. Place a dial indicator against the steering knuckle and insert a pry bar between the knuckle and control arm. Pry the steering knuckle and note the dial indicator reading. If the reading exceeds manufacturer's specifications, replace the ball joint.



III. Lubricating a suspension and steering system

(NOTE: Some steering joints are lubricated and sealed during assembly. Most ball joints and steering linkage joints, however, require periodic lubrication.)

A. Before lubricating a steering and suspension system, check the condition of all suspension joint seals. Replace any split, torn, or missing seals.

(NOTE: If the seal is an integral part of the joint, replace the entire joint.)

(**CAUTION:** Use a hand-operated, low-pressure grease gun. A high-pressure, air-operated gun can easily rupture seals, especially if used by a novice.)

B. To prevent contaminants from entering the joints, wipe all grease and dirt from each fitting. If the vehicle is equipped with plugs instead of fittings, remove each plug and install a temporary fitting. Reinstall the plugs after the joint is greased.

C. Snap the grease gun nozzle onto the fitting and force grease into the socket until the seal starts to swell. Wipe excessive grease from the joint.

(**CAUTION:** Do not continue to force lubricant into a socket after the seal starts to swell; doing so will rupture the seal. Make sure to use the proper grease. Most suspension and steering systems use an extreme pressure or EP grease.)

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR MEASURING VEHICLE RIDE HEIGHT

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Determine and record the specifications for the vehicle's ride height.
3. Determine and record the points from which the vehicle's ride height measurements are to be taken. If necessary, make a drawing showing the measuring points.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR INSPECTING BALL JOINTS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for visually inspecting the vehicle's ball joints.
3. Develop a written procedure for testing the condition of the load-carrying ball joints.
4. Develop a written procedure for testing the condition of the nonload-carrying ball joints.
5. Develop a written procedure for lifting the vehicle to unload the load-carrying ball joints.
6. Record all specifications related to ball joint movement.

MODULE: STEERING AND SUSPENSION SYSTEMS

MEASURING VEHICLE RIDE HEIGHT

Equipment:

Tape measure
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS1-L1-UIX. Using the information developed in items 2 and 3 of AS1-L1-UIX, measure the vehicle's ride height. Do the tasks outlined below before taking the measurements. ___ ___ ___ ___

   a. Inflate tires to the recommended pressure.

   b. Make sure the tires are of the proper size and type.

   c. Remove all unnecessary weight from the vehicle, such as luggage or other nonessential cargo.

      (NOTE: The fuel tank should be full when ride height measurements are taken. If the tank is not full, add equivalent weight to the vehicle. No one should sit in or lean on the vehicle while measurements are taken.)

   d. Clean all foreign material from the areas at which the measurements are to be taken.

   e. Jounce the vehicle vigorously, and allow the suspension to settle.

3. Measure the ride height of the vehicle at all 4 corners of the vehicle. ___ ___ ___ ___

4. Record the ride height measurements below. If the height is not correct, suggest procedures for solving the problem. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is the final evaluation for Competency S5. This average is also a partial evaluation for Competencies S1 and U2. Final evaluation for Competency S1 will be made at the end of JS5-L2-UX. Final evaluation for U2 will be made at the end of JS1-L3-UXVII.)

JS2-L1-UIX

MODULE: STEERING AND SUSPENSION SYSTEMS

TESTING BALL JOINTS

Equipment:

Hoist
Floor jack
Hand tools
Dial indicator or ball joint gauge
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Place the vehicle securely on safety stands or lift with hoist. ___ ___ ___ ___

   (**CAUTION:** Follow all the proper safety procedures and use the proper equipment when lifting a vehicle.)

3. **Complete AS2-L1-UIX. Following the procedure developed in item 2 of AS2-L1-UIX, evaluate the condition of the ball joints.** Use the chart below to indicate the condition of various ball joint parts. ___ ___ ___ ___

   Grease seal

   OK_____ NOT OK_____

   Grease fitting

   OK_____ NOT OK_____

   Stud nut/Cotter pin

   OK_____ NOT OK___

   Suggest repair procedures for any item marked "NOT OK" above.

4. Lower the vehicle. Following the procedure developed in item 3 of AS2-L1-UIX, evaluate the condition of the load-carrying ball joints. If necessary, unload the ball joints, using the procedure developed in item 5 of AS2-L1-UIX. Record observations. ____

5. Following the procedure developed in item 4 of AS2-L1-UIX, evaluate the condition of the nonload-carrying ball joints. Record findings below. ____

> (NOTE: MacPherson strut suspensions do not use nonload-carrying ball joints. When servicing a MacPherson strut assembly, skip item 5 above.)

6. Compare the specifications recorded in item 6 of AS2-L1-UIX to the results of the above tests. Based on the comparison, record the condition of the ball joints. ____

Average of above evaluations* ____

(*This average is a partial evaluation for Competencies S2 and S6. Final evaluation for S2 will be made at the end of JS4-L2-UX. Final evaluation for S6 will be made at the end of JS2-L1-UXI.)

MODULE: STEERING AND SUSPENSION SYSTEMS

LUBRICATING A STEERING AND SUSPENSION SYSTEM

Equipment:

Hoist
Grease gun
Hand tools
Safety glasses

Procedure: Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Place the vehicle securely on safety stands or lift with hoist. ___ ___ ___ ___

   (**CAUTION:** When lifting a vehicle, be sure to use the proper equipment and observe all applicable precautions.)

3. Record the type of lubricant recommended for the vehicle's steering and suspension. ___ ___ ___ ___

   Recommended lubricant ____________________

4. Inspect all steering and suspension joint grease seals. If any seals are torn or missing, they should be replaced. Record observations. ___ ___ ___ ___

5. Wipe all grease from each grease fitting. If plugs are used instead of fittings, install temporary fittings. ___ ___ ___ ___

6. Apply grease to each fitting until grease begins to flow out of the bleed area at the base of the seal or until the seal starts to swell. ___ ___ ___ ___

   (**CAUTION:** Do not continue to force lubricant into a socket after the seal starts to swell; doing so will rupture the seal.)

7. Apply a heavy film of grease to the steering stops on the steering knuckle and control arms. __ __ __ __

8. Wipe excessive grease from all joints, reinstall plugs, and lower vehicle. __ __ __ __

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competencies S2 and S6 . Final evaluation for S2 will be made at the end of JS4-L2-UX. Final evaluation for S6 will be made at the end of JS2-L1-UXI.)

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT IX: SLA SUSPENSION SYSTEM DIAGNOSIS AND LUBRICATION

UNIT IX TEST

PART I. DIAGNOSING CONVENTIONAL FRONT SUSPENSION SYSTEMS

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 1. Weak or broken suspension springs may cause the vehicle to handle poorly.

____ 2. Weak suspension springs can cause problems with the vehicle's alignment.

____ 3. A suspension problem will affect a vehicle's ride height.

____ 4. Ride height should usually be measured at the vehicle's bumper.

____ 5. Ride height is also known as curb height or chassis height.

____ 6. All tires should be at their correct pressure when a vehicle's ride height is checked.

____ 7. When a vehicle's ride height is checked, the fuel tank should be as close to empty as possible.

____ 8. A vehicle should contain no unnecessary weight when its ride height is checked.

____ 9. Before ride height measurements are taken, the vehicle should be jounced.

____ 10. Frame damage can affect a vehicle's ride height.

(NOTE: The student must obtain a minimum score of ____ on Part I of the Unit IX Test in order to receive an evaluation for Competencies S1 and U2.)

PART II. INSPECTING AND SERVICING BALL JOINT ASSEMBLIES

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 11. When inspecting a ball joint, the technician should routinely replace the grease seals regardless of their condition.

____ 12. Before testing ball joints, the technician should thoroughly shake the suspension.

____ 13. Inspection and test procedures are the same for load-carrying and nonload- carrying ball joints.

____ 14. Novice technicians should use a high-pressure grease gun to lubricate ball joints.

____ 15. Some steering joints are lubricated and sealed at the factory.

____ 16. Radial ball joint measurements that exceed specification can result in an improper micrometer measurement of the wheel bearings.

____ 17. Axial ball joint play is checked while the ball joint is unloaded.

____ 18. A technician must use a pry bar when testing an axial ball joint.

____ 19. Chassis grease is usually an SG lubricant.

____ 20. When testing ball joints, the technician should use a micrometer that can reach into tight areas.

____ 21. Some ball joints have wear indicators.

____ 22. Unloading a ball joint involves taking spring tension off the joint.

____ 23. Some ball joints should not be checked for radial looseness.

____ 24. Grease fittings or plugs should always be in place during ball joint inspection.

____ 25. Grease should be added to the ball joint until grease flows out of the seal.

(NOTE: The student must obtain a minimum score of ____ on Part II of the Unit IX Test in order to receive an evaluation for Competency S2.)

PART III. INSPECTING MACPHERSON STRUT BALL JOINTS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 26. The technician should check MacPherson strut ball joints by feeling for looseness in the ball joint grease fittings.

____ 27. MacPherson strut ball joints are load carrying.

____ 28. When inspecting MacPherson strut ball joints, the technician should check the ball joint stud nut and cotter pin.

____ 29. During inspection, the technician should make sure that the MacPherson strut suspension ball joint is loaded.

____ 30. Some MacPherson struts use no ball joints or control arms.

(NOTE: The student must obtain a minimum score of ____ on Part III of the Unit IX Test in order to receive an evaluation for Competency S6.)

ANSWERS TO UNIT IX TEST

1. t
2. t
3. f
4. f
5. f
6. t
7. f
8. t
9. t
10. t
11. f
12. t
13. f
14. f
15. t
16. t
17. f
18. t
19. f
20. f
21. t
22. t
23. t
24. t
25. f
26. t
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30. f

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT X: SERVICING CONVENTIONAL FRONT SUSPENSION SYSTEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and replace worn front suspension components. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the procedures for inspecting shock absorbers (Competencies S4 and T4, Part II of the Unit X Test).

II. Identify the procedures for inspecting and replacing the stabilizer bar (Competency S4, Part II of the Unit X Test).

III. Identify the procedures for inspecting and replacing strut rods and bushings (Competency S6, Part III of the Unit X Test).

IV. Demonstrate the ability to:

a. Inspect and replace front suspension shock absorbers (Competencies S1 and S4, JS1-L1-UX).

b. Inspect and replace stabilizer bars and bushings (Competencies S1 and S4, JS2-L1-UX).

c. Inspect and replace front suspension strut rods and bushings (Competency S6, JS3-L1-UX).

Lesson 2.

I. Identify the procedures for inspecting coil springs (Competencies S1 and S2, Part I of the Unit X Test).

II. Identify the procedures for replacing the coil spring on coil under suspension systems (Competencies S1 and S2, Part I of the Unit X Test).

III. Identify the procedures for removing and installing the coil spring on coil over suspension systems (Competency S2, Part I of the Unit X Test).

IV. Identify the procedures for replacing torsion bar springs (Competency S2, Part I of the Unit X Test).

V. Identify the procedures for servicing lower control arms (Competency S2, Part I of the Unit X Test).

VI. Identify the procedures for replacing upper control arms, cross shafts, and bushings (Competency S2, Part I of the Unit X Test).

VII. Identify the procedures for replacing the ball joint (Competency S2, Part I of the Unit X Test).

VIII. Demonstrate the ability to:

   a. Inspect and replace front suspension coil springs (Competencies S1 and S2, JS1-L2-UX).

   b. Inspect and replace front suspension torsion bar springs (Competencies S1 and S2, JS2-L2-UX).

   c. Inspect and replace front suspension upper control arms and bushings (Competencies S1 and S2, JS3-L2-UX).

   d. Inspect and replace front suspension lower control arms and bushings (Competencies S1 and S2, JS4-L2-UX).

   e. Inspect and replace upper and lower ball joints (Competencies S1 and S6, JS5-L2-UX).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D029, D031, D032, D033, D034, D036, D037, D038, D039, and D049.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT X: SERVICING CONVENTIONAL FRONT SUSPENSION SYSTEMS

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      JS1-L2-UX: Inspecting and Replacing Coil Springs
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      JS4-L2-UX: Inspecting and Replacing Lower Control Arms and Bushings
      JS5-L2-UX: Replacing Ball Joints

E. Unit test

F. Answers to unit test

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Moog Automotive Inc. Moog Front End Service Manual, Inspection and Service Procedures. St. Louis, Missouri: Moog Automotive Inc. 1986.

Toboldt, William K. and Johnson, Larry. Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair. South Holland, Illinois: The Goodheart-Willcox Company, Inc. 1981.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L1-UX in conjunction with JS3-L1-UX; AS1-L2-UX in conjunction with JS1-L2-UX; AS2-L2-UX in conjunction with JS2-L2-UX; AS3-L2-UX in conjunction with JS3-L2-UX; AS4-L2-UX in conjunction with JS4-L2-UX; and AS5-L2-UX in conjunction with JS5-L2-UX.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT X: SERVICING CONVENTIONAL FRONT SUSPENSION SYSTEMS

LESSON 1: INSPECTING AND REPLACING FRONT SUSPENSION CONTROL COMPONENTS

(NOTE: Always replace a suspension fastener with a fastener of the same type and quality. Using an improper fastener could cause suspension failure. Always adhere to the manufacturer's torque specifications when assembling suspension systems.)

(NOTE: Never heat, quench, straighten, or weld a suspension part. Always replace any worn or damaged parts.)

I. Inspecting and replacing the shock absorber

   A. Procedure for inspecting shock absorbers

      1. Raise and secure the vehicle.

         (NOTE: Be sure to raise the vehicle by the frame; doing so allows the control arms to hang unsupported, thus extending the shock absorbers.)

      2. Grasp the shock absorber and shake it. Note if it is mounted loosely. Inspect the condition of all rubber mounting bushings.

      3. Inspect the piston rod and outer tube for excessive fluid leakage. A light film of fluid around the top of the shock absorber is considered normal.

         (NOTE: If heavy fluid loss is noted, make sure the leakage is not from another source such as the power steering or engine. If the source of the leak is questionable, clean the shock and recheck it after a road test.)

      4. Inspect the shock tube and piston rod for signs of damage. Replace the shock if the tube is badly dented. Also check the piston rod for deep scratches, scoring, dents, or corrosion. Replace the shock if such damage is found.

         (NOTE: Small dents on the shock tube and light surface scratches on the rod are normal.)

   B. Procedure for removing, testing, and replacing a front shock absorber (independent front suspension)

      1. While holding the upper portion of the piston rod, loosen and remove the upper shock absorber retaining nut. Next, remove the washer and bushing.

         (NOTE: Do not hold the piston rod with a wrench or pliers. Use the flats provided at the end of the piston rod.)

      2. Raise the vehicle and secure it with safety stands.

      3. Remove the bolts that attach the lower end of the shock absorber to the lower control arm; then remove the shock absorber.

(NOTE: Once disconnected, a gas-charged shock will rapidly expand.)

(**CAUTION:** Do not apply heat or flame to gas-charged shocks.)

C. Procedure for testing the operation of the shock

(NOTE: Extreme force is required to compress gas-charged shocks; therefore, the following tests are difficult to perform on gas-charged shocks.)

(NOTE: During the below procedure, only one accessible end of the shock needs to be disconnected from the vehicle.)

1. Fully extend and compress the piston rod. Make sure the shock functions smoothly and quietly.

   (NOTE: Shock action should produce a faint swishing sound.)

   (NOTE: The shock will not necessarily have the same resistance when reacting to jounce as when reacting to rebound.)

2. If the shock functions erratically or makes unusual noise, hold it upright and once again extend it fully. Next, turn the shock over and compress it fully. Repeat this action three times to expel any air trapped in the hydraulic cylinder.

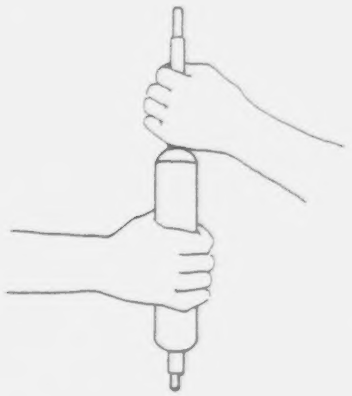
3. Position the shock upright in a vise.

4. Manually extend and compress the shock several times. If shock action is still erratic and/or noisy, replace the shock.

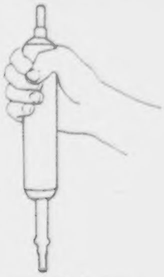
D. Procedure for bleeding air trapped in the shock

(NOTE: Always bleed any trapped air from the shock before installation.)

1. Hold the shock upright and fully extend it.



2. Invert the shock and slowly compress it as far as possible.



3. Repeat steps a and b several times.

E. Procedure for installing a front shock absorber

1. Fully extend the shock absorber and install the lower mounting washer and grommet on the upper end of the piston rod.

2. Insert the shock through the opening in the control arm and allow the piston rod stem to pass through the upper mounting hole.

3. Install the upper mounting grommet and washer; then install and tighten the retaining nut and bolt to the specified torque.

4. Install and tighten the nut and bolt that retain the lower end of the shock. Be sure to tighten the nut and bolt to the specified torque.

(NOTE: The procedure for installing a rear shock absorber is very similar to this procedure.)

II. Inspecting and replacing the stabilizer bar

A. Procedure for inspecting the stabilizer bar

1. Inspect the stabilizer bar for accident damage.

2. Inspect stabilizer bushings and links for deteriorated rubber or broken bolts and brackets.

3. Grasp the bar and shake it. Note any movement in bushings. Worn bushings should be replaced.

B. Procedure for removing the stabilizer bar

1. Raise and secure the vehicle.

2. Remove the link bolts or brackets that connect the stabilizer to the control arms.

3. Remove the brackets connecting the stabilizer to the frame. Next, remove the stabilizer and bushings.

C. Procedure for reinstalling the stabilizer bar

1. Reverse the removal procedures to reinstall the bar.

2. Replace any worn or deteriorated bushings or broken brackets.
3. Install all bushings as directed by the manufacturer.
4. Tighten all fasteners to the factory-specified torque.

III. Inspecting and replacing strut rods and bushings

A. Procedure for inspecting strut rods

(NOTE: Unless damaged in an accident, the strut rod will seldom need to be replaced.)

1. Inspect the rod for signs of physical damage. A bent bar will cause the wheel alignment to be incorrect.
2. Inspect the strut rod bushings for wear or deterioration. Loose strut rod bushings can affect wheel alignment and cause noise during acceleration and braking. Worn or deteriorated bushings should be replaced.

B. Procedure for removing a strut rod and bushings

1. Raise the vehicle on a frame lift hoist or use a jack and place safety stands under the frame.
2. Remove the front strut rod nut.
3. Remove the bolts attaching the strut rod to the control arm.
4. Slide the control arm out of the frame and remove the old bushings.

C. Procedure for inspecting a strut rod after removal

1. Check the general condition of the bushings. Make sure the bushings are not cracked or deteriorated.
2. Make sure the strut rod is straight and its threads are in good condition.

D. Procedure for installing a strut rod and bushings

1. Install the bushings on the strut rod.
2. Insert the strut rod and bushings into the subframe. Elevate the rear of the rod so it is level. Tighten the front nut; doing so ensures that the bushings will seat correctly.
3. Pull down on the rear of the rod and connect it to the control arm.
4. Tighten the fasteners to the factory-recommended torque.
5. Lower the vehicle.
6. Check and adjust alignment as necessary.

(NOTE: Care must be taken to locate the lower control arm in the correct position during installation of the strut rod or strut rod bushing.)

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR INSPECTING AND REPLACING STRUT RODS AND BUSHINGS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for safely removing the strut rod and bushings.
3. Develop a written procedure for safely reinstalling the strut rod and bushings. Make sure the procedure includes all necessary torque specifications.

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING SHOCK ABSORBERS

Equipment:

Hoist
Hand tools
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Place the vehicle securely on safety stands or lift with a hoist. __ __ __ __

   (**CAUTION:** Follow all the proper safety procedures and use the proper equipment when lifting a vehicle.)

3. Carefully inspect the shock absorbers. Complete the chart below. __ __ __ __

Securenessof mounting	OK____	NOT OK____
Condition of rubber bushings	OK____	NOT OK____
Excessive fluid leakage	OK____	NOT OK____
Condition of piston rod and tube	OK____	NOT OK____

   If any of the above items were marked "NOT OK," suggest appropriate repairs.

4. Following the procedure outlined below, remove the shock absorber. __ __ __ __

   a. Hold the piston rod to keep it from turning. Remove the upper shock absorber retaining nut, washer, and rubber bushing.

      (NOTE: Do not hold the piston rod with a wrench or pliers. Use the flats provided at the end of the piston rod.)

b. Remove the bolts holding the lower end of the shock absorber to the lower control arm; then remove the shock absorber.

5. Extend and compress the piston rod through several full strokes; then complete the chart below. _ _ _ _

(NOTE: Extreme force is required to compress gas-charged shocks; therefore, it may be difficult to perform this test on gas-charged shocks.)

Smooth action OK____ NOT OK____

Noise OK____ NOT OK____

Resistance to movement in both directions OK____ NOT OK____

Shock expands when released from compressed position (gas-charged only) OK____ NOT OK____

If any of the above items were marked "NOT OK," suggest appropriate repairs.

6. Hold the shock in an upright position and fully extend it. Next, turn the shock over and fully compress it. Repeat this action three times to expel any air trapped in the hydraulic cylinder. _ _ _ _

7. Once again extend and compress the piston rod through several full strokes and complete the chart below. __ __ __ __

Smooth action	OK_____	NOT OK_____
Noise	OK_____	NOT OK_____
Resistance to movement in both directions	OK_____	NOT OK_____
Expansion of gas-charged shock when released from compressed position	OK_____	NOT OK_____

If any of the above items were again marked "NOT OK," suggest appropriate repairs.

8. Following the procedure outlined below, install the shock absorber. __ __ __ __

   a. Using an appropriate service manual, determine and record in the space below all torque specifications related to shock absorber installation.

   b. Using the procedure described in step 6 of this job sheet, bleed any air trapped in the shock absorber.

   c. Fully extend the shock absorber and install the lower mounting washer and grommet on the piston rod.

d. Insert the shock through the opening in the control arm and allow the piston rod stem to pass through the upper mounting hole.

e. Install the upper mounting grommet and washer; then install and tighten the retaining nut to the specified torque.

f. Install and tighten the bolts that retain the lower end of the shock to the specified torque.

g. Lower the vehicle.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competencies S1 and S4. Final evaluation for S1 will be made at the end of JS5-L2-UX. Final evaluation for S4 will be made at the end of JS2-L1-UX.)

JS2-L1-UX

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING STABILIZER BARS AND BUSHINGS

Equipment:

Hoist
Hand tools
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Jounce the vehicle and note any noise produced by the stabilizer assembly. Record observations. ___ ___ ___ ___

3. Place the vehicle securely on safety stands or lift with hoist. ___ ___ ___ ___

   (**CAUTION:** Follow all the proper safety procedures and use the proper equipment when lifting a vehicle.)

4. Visually inspect the condition of the stabilizer bar, bushings, and links. Complete the below chart. ___ ___ ___ ___

   Condition of the stabilizer bar OK____ NOT OK____

   Condition of the stabilizer bar bushings OK____ NOT OK____

   Condition of mounting brackets and links OK____ NOT OK____

   If any of the above items were marked "NOT OK," suggest appropriate repairs.

5. Following the procedure outlined below, remove the stabilizer bar. __ __ __ __

   a. Remove the link bolts or brackets that attach the stabilizer to the control arms.

   b. Remove the brackets that attach the stabilizer to the frame and remove the stabilizer and bushings.

6. Inspect the condition of the bushings, brackets, and links. Record observations. __ __ __ __

7. Following the procedure outlined below, install the stabilizer. __ __ __ __

   a. Determine and record below all torque specifications related to the installation of the stabilizer.

   b. Reverse the removal procedures to install the stabilizer.

   c. Replace all damaged or missing parts as directed by the instructor.

   d. Lower the vehicle.

   Average of above evaluations* __ __ __ __

   (*This average is a partial evaluation for Competencies S1 and S4. Final evaluation for S1 will be made at the end of JS5-L2-UX. Final evaluation for S4 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency S4 by averaging the evaluations of JS1-L1-UX and JS2-L1-UX. Use the spaces provided below.

	Evaluation 3 2 1 N
JS1-L1-UX	__ __ __ __
JS2-L1-UX	__ __ __ __
Final evaluation for Competency S4	__ __ __ __

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING STRUT RODS AND BUSHINGS

Equipment:

Hoist
Hand tools
Safety glasses

Procedure:

		Evaluation 3 2 1 N
1.	Wear safety glasses while doing all procedures on this job sheet.	_ _ _ _
2.	Place the vehicle securely on safety stands or lift with a hoist.	_ _ _ _
	(**CAUTION:** Follow all the proper safety procedures and use the proper equipment when lifting a vehicle.)	
3.	Inspect the condition of the strut rods and bushings. Complete the chart below.	_ _ _ _

Strut rods OK____ NOT OK____

Strut bushings OK____ NOT OK____

If any of the above items were marked "NOT OK," suggest appropriate repairs.

4.	Complete AS1-L1-UX. Following the procedure developed in item 2 of AS1-L1-UX, remove the strut rod and bushings.	_ _ _ _
5.	Inspect the strut rod and bushings. Record observations.	_ _ _ _

6. Following the procedure developed in item 3 of AS1-L1-UX, install the strut rod and bushings. ____

7. Lower the vehicle. Check and reset all wheel alignment angles as necessary. See the instructor for wheel alignment procedures. ____

Average of above evaluations* ____

(*This average is a partial evaluation for Competency S6. Final evaluation for S6 will be made at the end of JS2-L1-UXI.)

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT X: SERVICING CONVENTIONAL FRONT SUSPENSION SYSTEMS

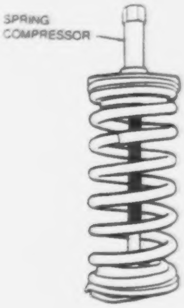
LESSON 2: INSPECTING AND REPLACING FRONT SUSPENSION SPRINGS, BALL JOINTS, AND CONTROL ARMS

I. Inspecting coil springs

- A. Always make sure the vehicle is at its proper ride height before checking the coil springs. The springs should be checked for collapsed or broken coils. The coils should be checked for shiny spots, which indicate coil spring clash (coils hitting together during jounce). Coil spring clash results from weak springs or shock absorbers.

- B. Make sure to follow the proper procedure and use the proper tools when servicing coil spring suspension systems. A compressor tool is required to remove and replace some springs.

  (**CAUTION:** When servicing coil springs, use only approved spring compressing tools. Compressing a spring with the wrong tool could result in serious personal injury.)



II. Replacing the coil spring on coil under suspension systems (the spring on the lower control arm)

(NOTE: Procedures for removing coil springs vary from manufacturer to manufacturer. Some procedures call for special tools to ensure the safe removal of the springs. The below procedures are general and will not apply to all springs. Always refer to the proper service manual for the appropriate procedure.)

- A. Procedure for removing coil springs
  1. Raise the vehicle and place safety stands under the frame.
  2. Remove the wheel and tire assembly from the vehicle.
  3. Remove the shock absorber from the vehicle.
  4. Install the spring compressor. Compress the spring according to procedures issued by either the vehicle or compressor manufacturer.

5. Remove the compressed spring from the vehicle.

6. Measure the length of the compressed spring. Note the positioning of the compressor on the spring. (The compressor must be positioned in the same way on the new spring.) Remove the spring compressor.

B. Procedure for inspecting coil springs and mountings

1. Disconnect the control arm at all points and then clean the spring mounting pads.

2. Inspect the control arm for signs of cracks and other damage.

3. Inspect the condition of the stud and the tapered hole in the steering knuckle. Replace any worn parts.

4. Inspect the condition of the control arm bushings and bolts. Replace any worn or damaged pieces.

5. Inspect the condition of the shock absorber. If one shock is found to be defective, replace both shocks.

6. Inspect the condition of any disconnected stabilizer and strut rod bushings. Replace them as necessary.

C. Procedure for reinstalling a coil suspension spring

1. Install the spring compressor on the new spring. Compress the new spring to the same length as the old spring. If the old spring used an insulator pad, transfer it to the new spring.

2. Install the compressed spring. Next, decompress the spring until it is properly seated. Remove the compressor tool.

3. Reconnect the shock absorber and the wheel.

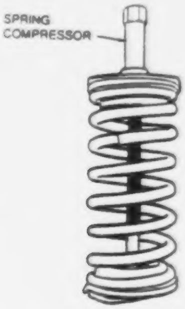
4. When spring installation is completed, move the vehicle at least 30 feet and park it on a flat, level surface. Jounce the vehicle several times. Allow the vehicle to settle out and check the chassis height.

5. Check and reset all alignment angles as necessary.

III. Removing and installing the coil spring on coil over suspension systems (spring on upper control arm)

A. Procedure for removing a coil spring

(NOTE: This procedure calls for a special spring compressing tool.)



1. Remove the shock absorber and upper shock mounting bracket as a single unit.
2. Raise the vehicle and place the safety stands under the control arms.
3. Remove the front wheel.
4. Remove the rubber rebound bumper bracket, if necessary.
5. Install the spring compressor. Compress the spring according to procedures issued by either the vehicle or compressor manufacturer.
6. Remove the compressed spring from the vehicle.
7. Measure the length of the compressed spring. Note the positioning of the compressor on the spring. (The compressor must be positioned in the same way on the new spring.) Remove the spring compressor.

B. Procedure for installing the coil spring

1. Install the spring compressor on the new spring. Compress the new spring to the same length as the old spring. If the old spring used an insulator pad, transfer it to the new spring.
2. Install the compressed spring. Next, decompress the spring until it is properly seated. Remove the compressor tool.
3. Reconnect the shock absorber, the rebound bumper bracket, and the wheel.
4. When spring installation is completed, move the vehicle at least 30 feet and park it on a flat, level surface. Jounce the vehicle several times. Allow the vehicle to settle out and check the chassis height.
5. Check and reset all alignment angles as necessary.

IV. Replacing torsion bar springs

(NOTE: Procedures for torsion bar removal and replacement vary considerably, depending on the design of either the vehicle or bar. The following procedure is, therefore, very general. Consult an appropriate service manual to obtain the specific procedures for the vehicle to be serviced.)

A. Procedure for removing a torsion bar spring

1. Raise the vehicle and place safety jacks under the frame. Make sure the wheels are in the full rebound position.

2. Turn the torsion bar anchor, adjusting bolt counterclockwise to release the load on the torsion bar.

   (NOTE: If removing transverse torsion bars, release the tension on both bars.)

3. Remove the torsion bar retainers and brackets; then, remove the torsion bar.

B. Procedure for inspecting a torsion bar

1. Inspect the seal and replace it if damaged.

2. Inspect torsion bar for nicks or scoring. Dress down any nicks or scoring to remove sharp edges. Paint repaired areas with a rust preventative.

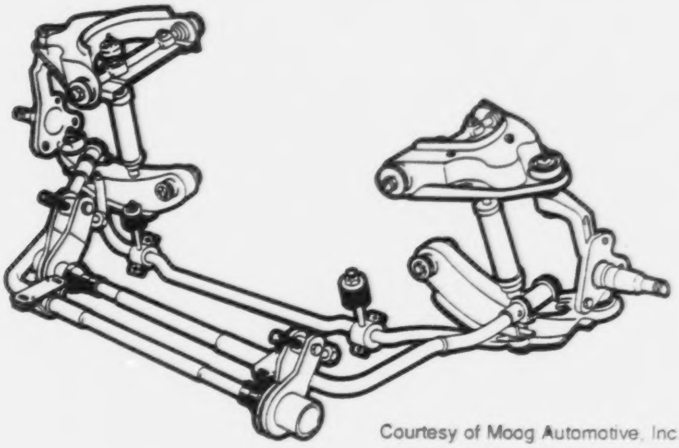
3. Inspect all mountings and bushings. Also inspect the adjusting bolt assembly. Replace all worn or damaged parts.

C. Procedure for reinstalling and adjusting a torsion bar

1. Reverse the removal procedure in order to reinstall the torsion bar.

2. After installation, turn the adjusting bolt clockwise to place a load on the torsion bar.

3. Lower vehicle and turn the adjusting bolt to achieve the correct front suspension height.



Courtesy of Moog Automotive, Inc.

V. Servicing lower control arms

A. Procedure for inspecting the lower control arm

1. Thoroughly clean the control arm.

2. Inspect the control arm carefully for cracks and other damage. Replace the control arm if defects are found.

3. Inspect the condition of the lower control arm bushings. Replace any worn or deteriorated bushings.

B. Procedure for removing lower control arms

1. Raise the vehicle and place safety stands under the frame. (If spring is on the upper control arm, place a wood block between the upper arm and the side rail before raising the vehicle.)

2. Remove the coil spring as outlined previously. (If the spring is on the upper control arm, the spring will not have to be removed.)

3. Using a taper breaker, disconnect the control arm from the ball joint.

4. Remove the control arm to the frame attaching bolts. (If the spring is on the upper arm, mark the position of the upper arm alignment cams.)

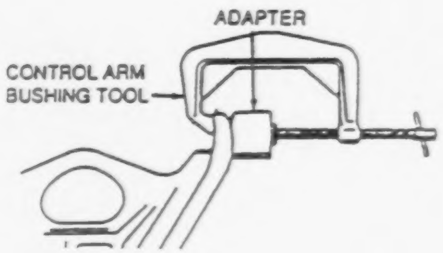
5. Lower the control arm out from under the vehicle.

C. Procedure for replacing lower control arm bushings

1. Place the control arm in a vise. Be careful not to crush the control arm in the vise.

2. Using a proper removal tool, force the old bushing(s) from the control arm.

3. Using a proper tool or press, install the new control arm bushing(s).



(NOTE: During bushing removal and installation, support the inside area of the control arm with a suitable spacer; doing so will ensure that the arm is not crushed or distorted.)

D. Procedure for installing a lower control arm

1. Reverse the removal procedures to reinstall the coil spring and control arm.

2. If the spring is on the upper arm, use the marks made before disassembly to position the alignment cams.

3. Tighten all fasteners to specified torque.

4. Check and adjust front-wheel alignment.

VI. Replacing upper control arms, cross shafts and bushings

A. Procedure for inspecting upper control arms

1. Make sure upper control arm bushings (made of rubber) are not distorted, off center, loose, or excessively cracked.

   (NOTE: Light cracks in the rubber bushing may be acceptable. If light cracks are discovered, inspect the bushing more closely to ensure that no other problems exist.)

2. Inspect the seals on metal bushings. Make sure that the metal bushings produce no unusual noise. Jounce the vehicle and listen for squeaking noises in the upper control arms. Noise is a sign of friction and wear.

3. Make sure that the nuts on the ends of the cross shaft are tight. These nuts sometimes become loose and allow the bushings to work their way out of the control arm.

B. Procedure for removing the upper control arm

1. Raise the vehicle and support the front of the vehicle with safety stands.

   (**CAUTION:** The positioning of the safety stands depends on the location of the spring. If the spring rests on the upper control arm, place the safety stands under the frame. If the spring rests on the lower control arm, place the safety stands between the spring seat and the ball joint.)

2. Remove the tire and wheel assembly.

3. Following the procedure outlined below, remove the upper ball joint from the steering knuckle.

   (NOTE: If the spring is on the upper control arm, use a spring compressor to relieve the spring tension. This procedure was described in the spring removal section above. The spring needs only to be compressed, not removed.)

   a. Remove the cotter pin from the tapered stud of the upper ball joint.

   b. Clean the threads on the end of the stud and loosen the nut two or three turns. Do not remove the nut at this time!

   c. Using a ball joint taper breaker, separate the stud from the knuckle.

   d. Remove the ball joint stud nut.

4. Remove control arm cross shaft nuts.

   a. Remove any alignment shims and note their position for reassembly.

   b. If a slotted alignment adjuster is used, scribe marks on the adjuster to show the position of the cross shaft. The marks will be referred to for reassembly.

5. Remove the control arm assembly from the car.

C. Procedure for replacing control arm bushings and shafts (rubber bushings)

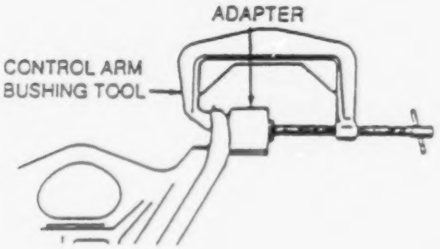
   1. Rubber bushings may be replaced by pressing or driving them in and out.

   2. Clamp the cross shaft to a bench vise to support the control arm.

   3. Remove the nuts from the ends of a cross shaft.

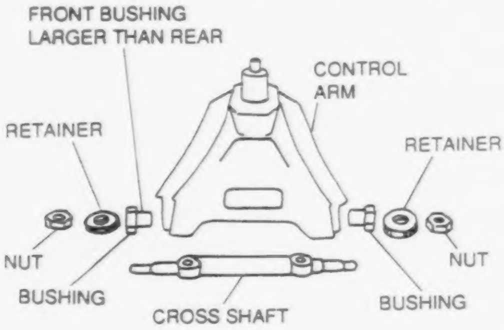
      (NOTE: Before removing the bushings, note their position in the control arm. Most bushings are pressed into the control arm until they contact a shoulder. Some bushings, however, are pressed to a specific depth. If the bushing does not contact a shoulder, measure and record the depth at which it is pressed into the control arm.)

   4. Using a special bushing removal tool, press the bushings from the control arm. The bushings can also be driven out with a pneumatic impact chisel.

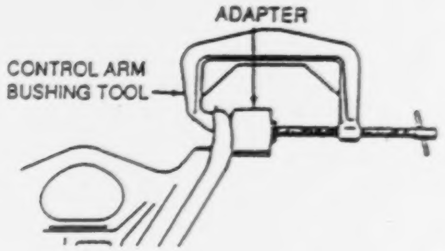


   5. Inspect the control arm for cracks and damage. Also inspect the arm for wear at the bushing holes. Replace any worn or damaged parts.

   6. Inspect the cross shaft for wear at the bushing pivot points.



7. Using a suitable tool, press the bushings into the control arm. Follow the procedure outlined below.



   a. Install the shaft in the arm before pressing the bushings into place.

   b. If pressure is being applied to the entire arm during assembly, place a spacer on the inner portion of the arm to prevent damage.

   c. The bushings may be driven into the control arm if a suitable driver is available. Support the control arm to prevent damage.

   d. Put the nuts on the cross shaft ends but do not tighten them completely. To prevent preloading the bushings, the nuts should be tightened after the arm has been installed and the vehicle is at curb height.

D. Procedure for replacing metal control arm bushings and shafts

1. Clamp the cross shaft in a vise to support the control arm.

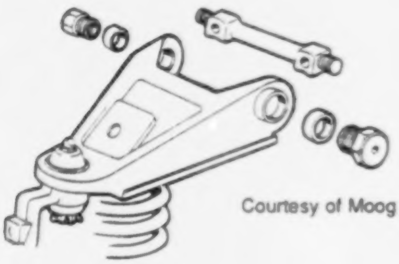
2. Loosen and remove the bushings with a socket and a breaker bar.

3. Position the shaft in the arm, apply grease to the new bushings and o-rings, and install the bushings on the shaft and arm. (Allow the bushings to remain loose at this point in the procedure.)

   a. Once the bushings are started into the control arm, locate and mark the center point between the mounting holes and the center of the control arm.

   b. Alternately tighten the bushings, keeping the reference marks perfectly aligned.

   c. Tighten the bushings to the specified torque and then lubricate them.



Courtesy of Moog Automotive, Inc.

E. Procedure for installing the control arm

1. To reinstall the control arm assembly, simply reverse the installation procedures.

2. Put alignment shims in the same position that they were in before removal. If a slotted alignment adjuster is used, align the cross shaft with the scribe marks made during removal.

3. After the arm is installed, lower the vehicle. Jounce the vehicle and allow it to settle to curb height; then tighten the cross shaft nuts to the specified torque.

   (NOTE: Failure to lower the vehicle before tightening the cross shaft nuts will preload the rubber bushings, causing them to twist excessively.)

4. Check and adjust wheel alignment as necessary.

VII. Replacing the ball joint

A. Ball joints are usually mounted in one of the three ways listed below.

1. The joint may be threaded into the control arm.

2. The joint may be riveted or bolted to the control arm.

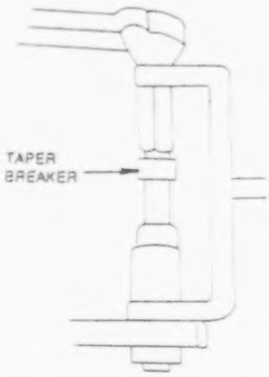
3. The joint may be pressed into the control arm.

   (NOTE: Service procedures vary for different types of ball joints.)

B. Special tools for ball joint service

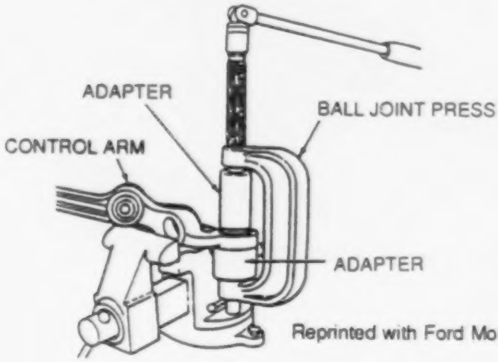
1. Most ball joints fit into the steering knuckle via a tapered stud arrangement similar to those used in steering linkages. A special taper-breaking tool should be used to remove the ball joint.

   a. One common taper-breaking tool is a screw press arrangement that fits between the upper and lower ball joint studs. As the nut on the screw is turned, the tool expands, forcing the stud out of the hole. Rapping the steering knuckle at the ball joint with a hammer while the stud is under pressure will release the taper.



b. A pickle fork can also be used to remove the ball joint. The pickle fork, however, will force the stud out of the hole as it is driven inward, thus destroying the joint.

2. A special tool is often needed to remove and replace press fit ball joints. The most common such device is a large C-clamp tool. Using different adapters that fit different ball joints, the C-clamp tool creates the force needed to remove and replace the press fit joints.



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C. Procedure for removing and replacing a load-carrying ball joint (spring on lower control arm)

1. Raise the vehicle and place jack stands under the lower control arm.

   (NOTE: Place a jack stand under the lower control arm at the spring seat to unload the ball joint and to retain the spring.)

   (**CAUTION:** The spring and control arm must always be retained during ball joint removal and installation.

2. Remove the tire and wheel assembly.

3. Remove the cotter pin from the ball joint stud. Loosen the castellated nut two or three turns. Do not remove the nut at this time!

   a. Using the proper ball joint taper breaker, break the taper between the ball joint stud and steering knuckle.

   b. Once the stud is free, remove the nut.

   c. Lift the spindle assembly so it is free of the ball joint. Place a wood block between the frame and upper control arm to keep the spindle out of the way.

5. Using the proper tool, remove the ball joint from the lower control arm.

   a. Use a special tool to force press fit joints out from the control arm.

   b. Use the proper socket to remove threaded ball joints from the control arm.

c. Use a chisel to remove a riveted ball joint. The chisel should be used only to cut the rivets. Be careful not to damage the control arm with the chisel.

6. Thoroughly clean and inspect the tapered hole in the steering knuckle. If the hole is damaged or worn, replace the steering knuckle. Clean the ball joint mounting area of the control arm. Inspect the area for cracking or distortion. Replace the arm if any problems are found.

7. Reverse the removal procedure to install the ball joints in the control arm. Tighten threaded ball joints to the specified torque.

   (NOTE: Riveted ball joints are usually replaced with bolts instead of rivets.)

8. Install the ball joint stud in the steering knuckle.

   a. Install the castellated nut on the stud and tighten to specified torque.

   b. Install a new cotter pin in the tapered stud.

      (NOTE: Never back off the castellated nut to align holes; always tighten to the next hole.)

   c. If the ball joint is equipped with a lubrication fitting or plug, lubricate the ball joint with the factory-specified grease.

D. Procedure for removing and replacing a nonload-carrying ball joint (spring on lower control arm)

1. Raise the front of the vehicle and place safety stands under the lower control arms. Because the weight of the vehicle is used to relieve spring tension on the upper control arm, place the stands as far outboard as possible to provide maximum leverage.

   (**CAUTION:** The spring and control arm must be retained throughout the removal and installation of the ball joint. Safety stands must, therefore, remain under the lower control arm at all times during these procedures.)

2. Remove the wheel and tire assembly.

3. Remove the cotter pin from the ball joint stud. Loosen the castellated nut two or three turns. Do not remove the nut at this time!

   a. Using a taper-breaking tool, break the taper between the ball joint stud and steering knuckle. Make sure to use the proper taper-breaking tool to avoid damaging the components.

   b. Once the stud is free, remove the nut.

   c. Lift up the upper control arm so it is free of the steering knuckle. Support the steering knuckle to prevent damage to the brake line.

4. Using the same procedure outlined for the load-carrying ball joint, remove the ball joint from the control arm.

5. Thoroughly clean and carefully inspect the tapered hole in the steering knuckle. If the hole is damaged or worn, the steering knuckle must be replaced. Clean the ball joint mounting area of the control arm. Inspect for cracking or distortion and replace the arm if problems are found.

6. Install the ball joint in the control arm by reversing the removal procedures.

7. Remove the temporary support from the steering knuckle and reattach the steering knuckle to the control arm.

   a. Install and tighten the castellated nut to the specified torque.

   b. Install a new cotter pin in the tapered stud.

      (NOTE: Never back off the castellated nut to align holes. Always tighten to the next hole.)

   c. If the ball joint is equipped with a lubrication fitting or plug, lubricate the ball joint with the factory-specified grease.

E. The procedure for replacing ball joints on vehicles with the spring on the upper control arm is similar with the exception of coil spring retention. Consult the appropriate service manual for procedures for replacing ball joints on vehicles which have the spring on the upper ball joint.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR INSPECTING AND REPLACING A FRONT SUSPENSION COIL SPRING

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for safely removing the coil spring.
3. Develop a written procedure for reinstalling the coil spring. Make sure the procedure includes all torque specifications related to installing the spring.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR INSPECTING AND REPLACING A TORSION BAR SPRING

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for safely removing and reinstalling the torsion bar spring. Make sure the procedure includes all torque specifications related to removing and reinstalling the spring.
3. Develop a written procedure for adjusting the vehicle ride height.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR INSPECTING AND REPLACING UPPER CONTROL ARMS AND BUSHINGS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for safely removing the upper control arm.
3. Develop a written procedure for safely removing and replacing the upper control arm shaft and bushings. Make sure the procedure includes all torque specifications related to upper control arm removal and replacement.
4. Develop a written procedure for safely installing the upper control arm. Make sure the procedure includes all torque specifications related to installing the control arm.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR INSPECTING AND REPLACING LOWER CONTROL ARMS AND BUSHINGS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for safely removing the lower control arm.
3. Develop a written procedure for replacing lower control arm bushings.
4. Develop a written procedure for safely installing the lower control arm. Make sure the procedure includes all torque specifications related to installing the control arm.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REPLACING BALL JOINTS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for safely removing the ball joint.
3. Develop a written procedure for installing the ball joint. Make sure the procedure includes all torque specifications related to installing the ball joint.

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING COIL SPRINGS

Equipment:

Hand tools
Hoist
Floor jack
Specialty tools
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Place the vehicle securely on safety stands or lift with hoist. ___ ___ ___ ___

   (**CAUTION:** Follow all the proper safety procedures and use the proper equipment when lifting a vehicle.)

3. Inspect the coil spring. Note any broken or collapsed coils. Also note any evidence of coil clash. Record observations. ___ ___ ___ ___

4. Complete AS1-L2-UX. Following the procedure developed in item 2 of AS1-L2-UX, remove the coil spring from the vehicle. ___ ___ ___ ___

   (**CAUTION:** Follow the manufacturer's instructions carefully during removal and installation; failure to do so could result in serious personal injury.)

5. Inspect the coil spring and related components. Complete the below chart. _ _ _ _

a. Control arms OK____ NOT OK____

b. Stud and the tapered hole in the steering knuckle OK____ NOT OK____

c. Disconnected control arm bushings and bolts OK____ NOT OK____

d. Shock absorber OK____ NOT OK____

e. Disconnected stabilizer and strut rod bushings OK____ NOT OK____

If any of the above items were marked "NOT OK," describe the problem and suggest appropriate repairs.

6. Following the procedure developed in item 3 of AS1-L2-UX, install the coil spring. _ _ _ _

a. Clean the spring mounting pads before installation.

b. Be sure to reinstall any rubber insulators before installing the spring.

c. Tighten all fasteners to specified torque.

7. Lower the vehicle. Move the vehicle (at least 30 feet) to a flat, level surface. Jounce the vehicle several times. Allow it to settle out and check chassis height. _ _ _ _

8. Check and reset all alignment angles as necessary. See the instructor for wheel alignment procedures. _ _ _ _

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competencies S1 and S2. Final evaluations for S1 will be made at the end of JS5-L2-UX. Final evaluation for S2 will be made at the end of JS4-L2-UX.)

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING TORSION BAR SPRINGS

Equipment:

Hoist
Hand tools
Specialty tools
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Complete AS2-L2-UX. Following the procedure developed in item 2 of AS2-L2-UX, remove the torsion bar spring. ___ ___ ___ ___

   (**CAUTION:** Follow the manufacturer's instructions carefully during removal and installation; failure to do so could result in serious personal injury.)

3. Inspect the torsion bar spring and related components. Fill out the below chart. ___ ___ ___ ___

   Seal (If used) OK_____ NOT OK_____

   Torsion bar (Look for nicks or scoring.) OK_____ NOT OK_____

   Adjusting bolt assembly, mounts and bushings OK_____ NOT OK____

   If any of the above items were marked "NOT OK," describe the problem and suggest appropriate repairs.

4. Following the procedure developed in item 3 of AS2-L2-UX, install the torsion bar spring. ___ ___ ___ ___

   a. Clean spring mounting points before installation.

   b. Replace all damaged or missing parts as directed by the instructor.

   c. Tighten all fasteners to specified torque.

5. Lower the vehicle. Following the procedure developed in item 4 of AS2-L2-UX, adjust the torsion bar ride height. ____

6. Check and reset all alignment angles as necessary. See the instructor for wheel alignment procedures. ____

Average of above evaluations* ____

(*This average is a partial evaluation for Competencies S1 and S2. Final evaluations for S1 will be made at the end of JS5-L2-UX. Final evaluation for S2 will be made at the end of JS4-L2-UX.)

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING UPPER CONTROL ARMS AND BUSHINGS

Equipment:

Hand tools
Hoist
Ball joint taper breaker
Specialty tools

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Inspect the condition of the control arm and bushing. Fill out the below chart. __ __ __ __

Control arm bushings	OK____	NOT OK____
Cross shaft nuts	OK____	NOT OK____
Control arm condition	OK____	NOT OK____

If any of the above items were marked "NOT OK," describe the problem and suggest appropriate repairs.

3. Complete AS3-L2-UX. Following the procedure developed in item 2 of AS3-L2-UX, remove the upper control arm from the vehicle. Also inspect the condition of the ball joint seal and tapered stud. Check the tapered hole in the steering knuckle for wear. Record observations. __ __ __ __

(NOTE: Mark the position of the control arm. Note the position of alignment shims when applicable.)

(**CAUTION:** Follow the manufacturer's instructions carefully during removal and installation; failure to do so could result in serious personal injury.)

4. Following the procedure developed in item 3 of AS3-L2-UX, replace the control arm shaft and bushings. — — — —

   (NOTE: Do not tighten the cross shaft nuts on control arms with rubber bushings until the control arms are reinstalled and the vehicle is sitting at its normal ride height.)

5. Following the procedure developed in item 4 of AS3-L2-UX, reinstall the control arm on the vehicle. — — — —

   a. Clean all mounting points on the control arm and frame before beginning installation procedures.

   b. Reinstall the control arm either by aligning the marks made before removal or by installing the alignment shims in the same positions.

   c. Tighten all fasteners to the specified torque.

   d. Do not tighten cross shaft nuts on control arms using rubber bushings until the vehicle is at rest on the floor.

   e. Lower vehicle.

   f. Tighten cross shaft nuts, if necessary.

6. Check and reset all alignment angles as necessary. See the instructor for wheel alignment procedures. — — — —

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competencies S1 and S2. Final evaluations for S1 will be made at the end of JS5-L2-UX. Final evaluation for S2 will be made at the end of JS4-L2-UX.)

JS4-L2-UX

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING LOWER CONTROL ARMS AND BUSHINGS

Equipment:

Hand tools
Hoist
Ball joint taper breaker
Specialty tools
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Inspect the condition of the control arm and bushing. Complete the below chart. __ __ __ __

Control arm bushings OK____ NOT OK____

Control arm condition OK____ NOT OK____

Noise when jounced OK____ NOT OK____

If any of the above items were marked "NOT OK," describe the problem and suggest appropriate repairs.

3. Complete AS4-L2-UX. Following the procedure developed in item 2 of AS4-L2-UX, remove the lower control arm from the vehicle. Also inspect the condition of the ball joint seal and tapered stud. Check the tapered hole in the steering knuckle for wear. Record observations. __ __ __ __

(NOTE: Mark the position of the alignment cams on vehicles that have the spring on the upper control arm.)

(**CAUTION:** Follow the manufacturer's instructions carefully during removal and installation; failure to do so could result in serious personal injury.)

4. Following the procedure developed in item 3 of AS4-L2-UX, replace the lower control arm bushings. — — — —

   (NOTE: To prevent crushing the control arm, be sure to support the inner portion of the control arm when pressing bushings.)

5. Following the procedure developed in item 4 of AS4-L2-UX, reinstall the control arm on the vehicle. — — — —

   a. Clean all mounting points on the control arm and frame before beginning installation procedures.

   b. Reinstall the control arm. When installing the arm on vehicles that have the spring on the upper arm, align the marks made before removal.

   c. Tighten all fasteners to the specified torque.

6. Lower vehicle. Check and reset all alignment angles as necessary. See the instructor for wheel alignment procedures. — — — —

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competencies S1 and S2. Final evaluation for S1 will be made at the end of JS5-L2-UX. Final evaluation for S2 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. **Determine the student's final evaluation** for Competency S2 by averaging the evaluations of JS2-L1-UIX, JS3-L1-UIX, JS1-L2-UX, JS2-L2-UX, JS3-L2-UX, and JS4-L2-UX. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS2-L1-UIX	___	___	___	___
JS3-L1-UIX	___	___	___	___
JS1-L2-UX	___	___	___	___
JS2-L2-UX	___	___	___	___
JS3-L2-UX	___	___	___	___
JS4-L2-UX	___	___	___	___
Final evaluation for Competency S2	___	___	___	___

JS5-L2-UX

MODULE: STEERING AND SUSPENSION SYSTEMS

REPLACING BALL JOINTS

Equipment:

Hand tools
Hoist
Serviceable vehicle
Ball joint taper breaker
Specialty tools
Safety glasses

Procedure:		Evaluation 3	 2	 1	 N
1.	Wear safety glasses while doing all procedures on this job sheet.	__	__	__	__
2.	Check the condition of the ball joints. Refer to JS2-L1-UIX for this procedure. Record observations.	__	__	__	__
3.	Complete AS5-L2-UX. Following the procedure developed in item 2 of AS5-L2-UX, remove the ball joint.	__	__	__	__
4.	Thoroughly clean and carefully inspect the tapered hole in the steering knuckle. Clean the ball joint mounting area of the control arm. Inspect for cracking or distortion. Record observations.	__	__	__	__
5.	Following the procedure developed in item 3 of AS5-L2-UX, install and lubricate the ball joint. Refer to JS3-L1-UIX for the lubrication procedure.	__	__	__	__

6. Lower vehicle. Check and reset all alignment angles as necessary. See the instructor for wheel alignment procedures. __ __ __ __

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competency S1 and S6. Final evaluation for S1 will be made below. This job sheet can also be an evaluation for S6 if the job sheet procedures are used on a MacPherson strut vehicle. Final evaluation for S6 will be made at the end of JS2-L1-UXI.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency S1 by averaging the evaluations of JS1-L1-UIX, JS1-L1-UX, JS2-L1-UX, JS1-L2-UX, JS2-L2-UX, JS3-L2-UX, JS4-L2-UX, and JS5-L2-UX. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L1-UIX				
JS1-L1-UX				
JS2-L1-UX				
JS1-L2-UX				
JS2-L2-UX				
JS3-L2-UX				
JS4-L2-UX				
JS5-L2-UX				
Final evaluation for Competency S1				

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT X: SERVICING CONVENTIONAL FRONT SUSPENSION SYSTEMS

UNIT X TEST

PART I. INSPECTING CONTROL ARMS AND SPRING ASSEMBLIES

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. The vehicle's ride height should always be checked after its springs are replaced.

____ 2. Torsion bar springs allow for the adjustment of ride height.

____ 3. Coil spring pads are left out during assembly.

____ 4. A vehicle's ride height should be measured before its springs are checked.

____ 5. Coil clash will cause shiny spots to appear on torsion bar springs.

____ 6. A spring compressor must be used during removal of some coil springs.

____ 7. A variety of common shop tools can be used to compress a spring.

____ 8. After the springs are replaced, wheel alignment should be checked.

____ 9. The torsion bar springs should be checked for spring clash.

____ 10. The control arm should be cleaned before it is inspected.

____ 11. A vise should be used to hold control arms during service.

____ 12. The tire and wheel assembly is not usually removed during upper control arm removal.

____ 13. Ball joint removal procedures may vary, depending on suspension design.

____ 14. A lock nut is usually used to bolt the spindle to the ball joint.

____ 15. Ball joints that are riveted to the suspension are usually replaced by ball joints which are bolted to the suspension.

SECTION B. **Select the best answer from the five choices listed.**

____ 16. Weak springs and/or shock absorbers may cause

a. wheel imbalance.
b. spring clash.
c. suspension breakage.
d. brake wear.
e. all of the above.

____ 17. Control arms should be inspected for

a. cracks and physical damage.
b. rust holes.
c. accident damage.
d. metal fatigue.
e. all of the above.

____ 18. During an inspection of the coil spring and mountings, the technician must be sure to check

a. the tapered hole in the steering knuckle.
b. the shock absorber.
c. the stabilizer bar bushings.
d. the strut rod bushings.
e. all of the above.

____ 19. When replacing a spring that uses an insulator pad, the technician should

a. throw the pad away.
b. replace the pad with a new insulator.
c. tape the pad to the new spring before installation.
d. soak the pad in solvent.
e. do none of the above.

____ 20. When removing torsion bar springs, the technician should

a. support the vehicle under the frame.
b. spin the rear wheels as hard as possible.
c. place extra weight on the rear of the vehicle.
d. turn the front wheels to the left.
e. do none of the above.

____ 21. Before removing the lower control arm, the technician should first remove

a. the spring.
b. the ball joint.
c. the shock.
d. the stabilizer bar.
e. all of the above.

____ 22. Control arm bushings should be inspected for

a. wear.
b. badly deteriorated rubber.
c. distortion.
d. off center positioning.
e. all of the above.

____ 23. When inspecting metal control arm bushings, the technician should

a. disconnect the battery.
b. turn the front wheels hard from left to right.
c. look for metal filings.
d. drive the vehicle both forward and backward.
e. do all of the above.

___ 24. When removing upper control arms, the technician should

a. throw away all the old alignment shims.
b. throw away all the old slotted alignment adjusters.
c. use the vehicle's weight to unload the upper control arm.
d. use the taper breaker to separate the ball joint stud from the steering knuckle.
e. do none of the above.

___ 25. The upper control arm and cross shaft are inspected for wear at the

a. bushing pivot points.
b. stabilizer bar bushings.
c. ball joint bushings.
d. spring seat.
e. alignment shims.

___ 26. When replacing rubber control arm bushings, the technician should support the control arm to prevent damaging the

a. bushing.
b. control arm.
c. cross shaft.
d. alignment slot.
e. steering column.

___ 27. When replacing metal control arm bushings, the technician should

a. mark the center point between the mounting holes.
b. mark the center of the control arm.
c. alternately tighten the bushings.
d. tighten the bushings to specified torque.
e. do all of the above.

___ 28. Ball joints are either

a. threaded, rivetted, or pressed onto the vehicle.
b. bolted, pressed, or heat fitted onto the vehicle.
c. welded, forged, or stamped onto the vehicle.
d. rivetted, cast, or forged onto the vehicle.
e. heat fitted, welded, or cast onto the vehicle.

___ 29. The control arm can easily be damaged during removal of

a. welded-type ball joints.
b. cast-type ball joints.
c. bolted-type ball joints.
d. rivetted-type ball joints.
e. heat-fitted ball joints.

____ 30. When removing ball joints on a lower control arm, the technician should always support the lower control arm with a safety stand or jack in order to

a. retain the spring.
b. support the vehicle.
c. prevent the steering knuckle from flying out.
d. prevent the shock from leaking.
e. do none of the above.

(NOTE: The student must obtain a minimum score of ____ on Part I of the Unit X Test in order to receive an evaluation for Competencies S1 and S2.)

PART II. INSPECTING AND REPLACING SHOCK ABSORBERS AND STABILIZER BARS

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 31. The suspension should be unloaded during inspection to extend shock absorbers.

____ 32. Most rubber shock bushings never wear out.

____ 33. If the body of a shock is dented excessively, it should be replaced.

____ 34. All air should be bled from a shock before it is installed.

____ 35. Shocks should be checked for fluid leaks.

---- 36. Worn stabilizer bar bushings should always be replaced.

SECTION B. Select the best answer from the five choices listed.

____ 37. Shock inspection includes

a. checking shock mounting.
b. checking for leaks.
c. checking for physical damage.
d. testing the operation of the shock.
e. all of the above.

____ 38. When testing the operation of the shock, the technician should

a. move the piston through the full range of motion.
b. make sure the shock moves smoothly and uniformly.
c. listen for unusual noises.
d. grasp the shock to check the grommets.
e. do all of the above.

____ 39. To check variance of shock motion, the technician should hold the shock in an upright position and fully extend it and then invert the shock and compress it

a. completely.
b. 2/3 the length of the piston.
c. 1/2 the length of the piston.
d. 1/3 the length of the piston
e. 1/6 the length of the piston.

____ 40. Shock mounting grommets should be tightened until the

a. washer is snug on the grommet.
b. grommet shoulders are squeezed out of the washer sides.
c. specified torque is achieved.
d. shock shaft is flush with the frame.
e. shock shaft begins to turn.

____ 41. When replacing a shock, the technician should

a. shake the shocks to check for looseness.
b. secure the vehicle on safety stands.
c. coat the shock with oil.
d. submerge the shock in solvent.
e. do all of the above.

____ 42. The stabilizer bar should be checked for

a. accident damage.
b. secureness of mounting.
c. deterioration of bushings or links.
d. breakage of bolts and brackets.
e. all of the above.

____ 43. In order to remove the stabilizer bar, the technician should

a. remove the link bolts that connect the bar to the control arms.
b. remove the brackets that connect the springs to the frame.
c. raise and secure the vehicle.
d. remove the lower control arms.
e. remove the shock absorbers.

____ 44. How much movement should stabilizer bar bushings have?

a. none.
b. 1/4 of an inch.
c. 3/8 of an inch.
d. 1/2 of an inch.
e. none of the above.

____ 45. Stabilizer bars should be inspected for damage caused as a result of

a. neglect.
b. accident or collision.
c. weak shocks.
d. weak springs.
e. bent or broken suspension parts.

(NOTE: The student must obtain a minimum score of ____ on Part II of the Unit X Test in order to receive an evaluation for Competencies S4 and T4.)

PART III. CLEANING, INSPECTING, AND ASSEMBLING STRUT ROD ASSEMBLIES

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 46. Before strut rod removal, safety stands should be placed under the frame.

____ 47. When removing the strut rod, remove the bolts attaching the strut rod to the control arm first.

____ 48. Strut rod bushings should be checked for traces of strut rod oil.

____ 49. Strut rods should be checked for the proper bends.

____ 50. Changing strut rods does not affect alignment.

(NOTE: The student must obtain a minimum score of ____ on Part III of the Unit X Test in order to receive an evaluation for Competency S6.)

ANSWERS TO UNIT X TEST

1.	t
2.	t
3.	f
4.	t
5.	t
6.	t
7.	f
8.	t
9.	f
10.	t
11.	f
12.	f
13.	t
14.	f
15.	t
16.	b
17.	e
18.	e
19.	c
20.	e
21.	e
22.	e
23.	c
24.	d
25.	a
26.	a
27.	e
28.	a
29.	d
30.	a
31.	t
32.	f
33.	t
34.	t
35.	t
36.	t
37.	e
38.	e
39.	a
40.	a
41.	b
42.	e
43.	a
44.	e
45.	b
46.	t
47.	f
48.	f
49.	f
50.	f

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XI: MACPHERSON STRUT SUSPENSION SERVICE

UNIT OBJECTIVE

After completing this unit, the student should be able to identify and replace worn Macpherson strut suspension components and diagnose problems related to MacPherson strut suspensions. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify the basic components of MacPherson struts (Competencies S5, S6, and T3, Parts I and II of the Unit XI Test).

II. Identify the procedures for diagnosing and inspecting MacPherson strut suspensions (Competencies S5 and T3, Parts I and II of the Unit XI Test).

III. Identify the procedures for servicing MacPherson struts (Competencies S6 and T3, Part II of the Unit XI Test).

IV. Identify the procedures for servicing modified MacPherson struts (Competencies S6 and T3, Part II of the Unit XI Test).

V. Demonstrate the ability to:

   a. Inspect, remove, and install Macpherson strut assemblies (Competencies S6 and T3, JS1-L1-UXI).

   b. Replace MacPherson strut dampeners, springs, and mounts (Competencies S6 and T3, JS2-L1-UXI).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D030, D040, D041, D046, and D047.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XI: MACPHERSON STRUT SUSPENSION SERVICE

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plan

Lesson 1: SERVICING FRONT MACPHERSON STRUT SUSPENSIONS

- a. Information outline
- b. Assignment sheets
  - AS1-L1-UXI: Procedures for Inspecting, Removing, and Installing MacPherson Strut Assemblies
  - AS2-L1-UXI: Procedures for Replacing MacPherson Strut Dampeners, Springs, and Mounts
- c. Job sheets
  - JS1-L1-UXI: Inspecting, Removing, and Installing MacPherson Strut Assemblies
  - JS2-L1-UXI: Replacing MacPherson Strut Dampeners, Springs, and Mounts

E. Unit test

F. Answers to unit test

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Chrysler Corporation. Service Manual, Rear Wheel Drive 1985 Passenger Cars. Chrysler Corporation. 1984.

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Moog Automotive Inc. Moog Front End Service Manual, Inspection and Service Procedures. St. Louis, Missouri: Moog Automotive Inc. 1986.

Toboldt, William K. and Johnson, Larry. Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair. South Holland, Illinois: The Goodheart-Willcox Company, Inc. 1981.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UXI in conjunction with JS1-L1-UXI and AS2-L1-UXI in conjunction with JS2-L1-UXI.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XI: MACPHERSON STRUT SUSPENSION SERVICE

LESSON 1: SERVICING FRONT MACPHERSON STRUT SUSPENSIONS

I. A MacPherson strut incorporates a shock absorber and a coil spring in a single unit. Usually the entire strut assembly must be removed before either the spring, the dampener, or the top strut can be removed.

II. Diagnosing and inspecting MacPherson strut suspensions

(NOTE: Suspension systems using MacPherson struts are diagnosed in much the same way as conventional front suspensions.)

A. Procedure for inspecting ball joints

1. MacPherson strut suspension systems use only a lower ball joint. On MacPherson struts, the looseness of a ball joint is measured in much the same way as on conventional front suspensions. The measuring procedures do, however, vary slightly from manufacturer to manufacturer.

(NOTE: The ball joint used with a MacPherson strut suspension system is a nonload-carrying ball joint.)

2. Instructions for measuring ball joint looseness and inspecting ball joint condition on both conventional and MacPherson strut front suspension are outlined in Unit IX of this module. Procedures for visually inspecting ball joints on MacPherson struts are the same as those for inspecting ball joints on conventional front suspensions. Always consult the appropriate service manual before inspecting ball joints.

B. Strut rods are used on most MacPherson strut front suspensions. As with conventional suspensions, strut rods help to support and control the lower control arms. Strut rods on MacPherson struts are inspected in the same manner as strut rods on conventional front suspensions.

C. Stabilizer bars used with Macpherson struts are similar to stabilizer bars used on conventional suspensions. Inspection and diagnosis procedures for stabilizer bars on MacPherson struts are the same as for inspection and diagnosis procedures for conventional front suspension stabilizer bars.

D. Although coil springs are mounted differently on MacPherson strut suspensions, the procedures for inspecting the springs are the same as for coil springs on short-long-arm suspensions. The best way to diagnose weak coil springs on a MacPherson strut suspension is to measure vehicle ride height.

E. On a MacPherson strut, the dampener serves the same purpose as a shock absorber. However, the strut dampener is enclosed in the strut tube and is, therefore, more difficult to inspect and diagnose than a conventional shock absorber. Below is a general procedure for checking strut dampeners. For more specific procedures, refer to the proper service manual for the vehicle to be serviced.

1. Jounce the vehicle. If the vehicle bounces more than twice, the dampeners are weak.

2. Jounce the vehicle again and listen for any unusual noises. Unusual noises may mean the dampener is defective.

3. As was stated above, the dampener is enclosed within the strut. Visually inspect the strut for signs of oil that may be leaking from the dampener. Repair or replace the dampener if leaks are found.

   (NOTE: When inspecting the strut for oil leaks, make sure that the oil is actually coming from the dampener before making any repairs. Oil on the strut may be from the engine, the power steering system, or some other source.)

F. Procedure for inspecting and diagnosing the top strut mount

1. With the weight of the vehicle resting on the floor, turn the steering wheel to the left and right.

2. Note any binding or popping in the strut assemblies as the steering wheel is turned. Binding or noise can be caused by a defective upper strut mount bearing, which prevents the strut from rotating smoothly.

3. Raise the vehicle from under the frame, allowing the suspension to hang free.

   (**CAUTION:** Always use the proper equipment and observe all safety rules when raising a vehicle.)

4. Place a pry bar under each front tire and pry upward while noting any excessive looseness in the upper strut mount.

5. Check the manufacturer's service manual for specifications concerning looseness in the upper mount. Some manufacturers allow a good deal of movement in the mount.

III. Servicing MacPherson struts

A. Procedures for removing MacPherson struts

1. Raise the vehicle's hood and loosen the upper strut to the body nuts. Place a mark on one of the studs and a corresponding mark on the vehicle body. These marks will serve as reference points during reassembly.

2. Hoist the vehicle under the frame, allowing the front suspension to hang free.

3. Remove the tire and wheel assembly.

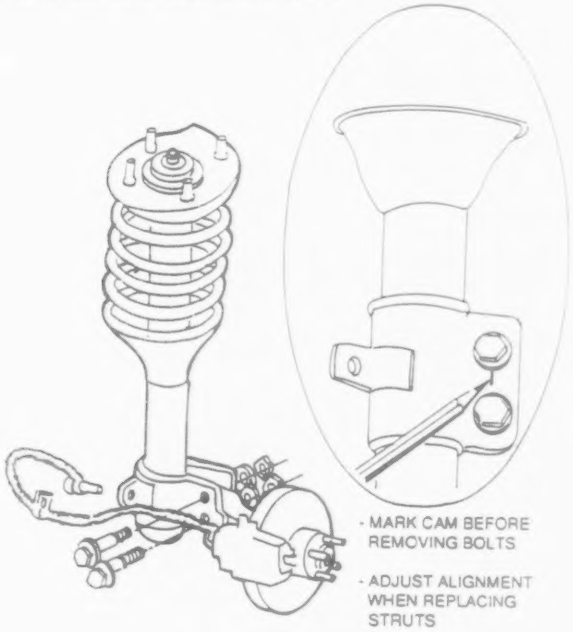
4. If necessary, remove the brake line from the mounting bracket on the strut tube. Doing so may require that a brake hose be disconnected from a brake line. The brakes will then have to be bled after assembly.

5. Either remove the lower mounting bolts holding the strut to the steering knuckle or separate the ball joint taper (depending on the way the strut is attached to the vehicle).

(NOTE: If the strut is attached to the knuckle with bolts, one of the bolts may have an eccentric washer used for adjusting the alignment. If so, mark the position of the washer on the strut before removal.)

6. Finish removing the upper strut to body nuts.

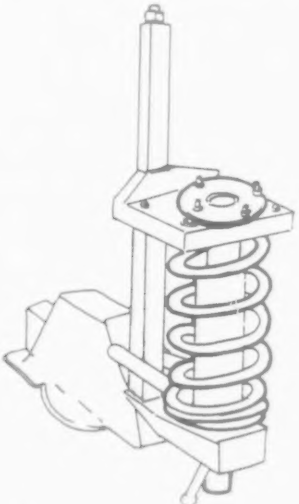
7. Remove the strut from the vehicle.


- MARK CAM BEFORE REMOVING BOLTS
- ADJUST ALIGNMENT WHEN REPLACING STRUTS

B. Procedure for disassembling the MacPherson strut

1. Once removed from the vehicle, the strut dampener, and the spring and top mount can be disassembled and serviced.

2. Before the strut can be disassembled, the spring must be compressed by using a special spring compressor. The illustration below shows a typical compressor.



(**CAUTION:** Be sure to use the proper type of spring compressor to compress a spring. Attempting to use some other type of tool could result in serious injury to people working in the immediate area. Never disassemble a strut without first relieving the spring tension.)

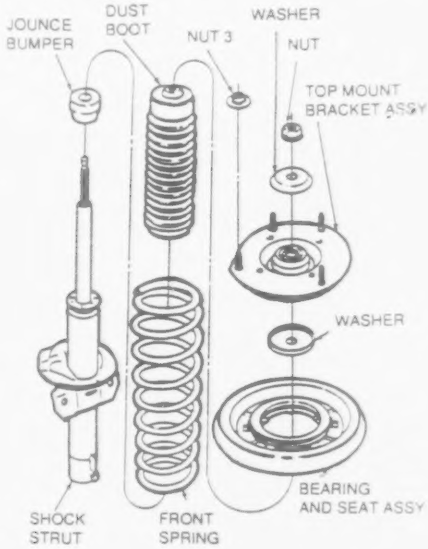
3. Place the spring compressor in a vise. Mount the strut in the spring compressor according to the tool manufacturer's instructions.

   (NOTE: If the spring compressor is not designed to support the strut, a strut holding fixture will have to be used. Never clamp the strut tube in a vise. Doing so may crush the strut.)

4. Compress the spring and remove the retaining nut from the top of the strut.

   (NOTE: Never bottom the spring or the strut dampener rod.)

5. Remove the top mount assembly, the protective boot, and the jounce bumper. To aid reassembly of the strut, arrange all parts in the order that they are removed.



6. Loosen the spring compressor to relieve the tension on the coil spring.

7. Remove the strut and spring from the compressor.

C. Replacing strut dampeners

(NOTE: In many vehicles, the dampener cannot be replaced and is serviced along with complete strut after the spring is removed.)

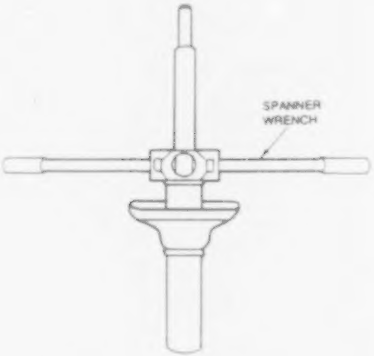
1. Strut dampeners may be either the sealed type or the repairable type.

2. Once the spring and top mount is removed, the sealed strut dampener and strut housing are serviced as a complete unit.

3. The repairable dampener is a part of a removable dampener assembly, which fits inside the existing strut housing. Below is a procedure for disassembling, servicing, and reassembling the dampener.

    a. Remove the dampener piston rod assembly, the cylinder, and the fluid either after the piston rod nut is removed from the upper end of the strut housing or after the end of the strut tube is removed.

       (NOTE: A pipe cutter is often used to remove the end of the strut tube. See the manufacturer's directions for the exact procedures.)



    b. Thoroughly clean the housing after it is removed.

       (NOTE: It is very important to maintain cleanliness during repair of strut dampeners.)

    c. New parts should be lubricated with the specified strut dampener fluid when they are installed.

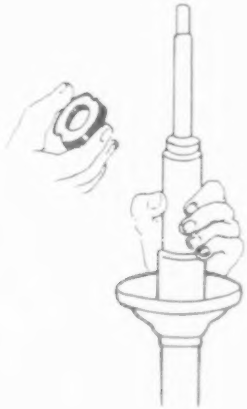
    d. Fill the dampener with a specified amount of fluid. See manufacturer's specifications for the correct type and amount of fluid to use. The piston rod will need to be moved slowly to expel air as fluid is added.

    e. Install the piston rod guide and o-ring.

    f. Install the piston rod nut. Seal and torque the nut to specifications.

4. A sealed dampener cartridge is similar to a conventional shock absorber. The cartridge greatly simplifies installation of the dampener unit. Below is a procedure for installing the cartridge.

a. Place the strut cartridge inside of the strut tube in place of the original dampener.



b. Sometimes the manufacturer recommends that a small amount of oil be added to the strut housing to help dissipate heat.

c. Install the piston rod nut in the top of the strut housing.

D. Procedures for inspecting strut components

1. Once the spring is removed, the dampener bench is tested by using the same procedure as the shock absorber.

   (NOTE: Strut dampeners are more easily compressed and extended than are conventional shock absorbers.)

2. Inspection procedures for MacPherson strut coil springs are the same as inspection procedures for conventional suspension coil springs. Refer to Unit X for spring inspection procedures.

3. Procedure for inspecting the strut housing

   a. Inspect the housing for signs of physical damage.

   b. Inspect the condition of welds at the lower mounting bracket and at the lower spring mount.

4. Procedure for inspecting the top strut mount

   a. Inspect the condition of the mount. If the mount is badly deteriorated, it should be replaced.

   b. Inspect the bearing for looseness.

   c. Make sure the bearing operates smoothly.

   d. Inspect the condition of the jounce bumper.

   e. Inspect the condition of the dust boot.

E. Procedure for reassembling the strut

1. Place the strut spring compressor in a vise.
2. Compress the spring and install the strut, the upper spring seat, and the top mount.

   (NOTE: Make sure the spring is properly seated on the spring seat. Some manufacturers require the upper spring seat to be aligned with the lower spring seat and the lower strut mounting bracket.)
3. Install the retaining nut and tighten it to factory specifications.

F. Procedures for installing the strut

1. Install the strut in reverse order of disassembly.
2. Align the upper stud with the mark placed on the vehicle body during disassembly.
3. Align the eccentric washer with the mark on the strut to achieve approximate alignment.
4. If a brake line was disconnected, reconnect and bleed the brake system.
5. Tighten all fasteners to specified torque.
6. Check front wheel alignment and set all adjustable angles.

IV. Servicing modified MacPherson struts

A. Servicing modified MacPherson struts involves service techniques for both conventional suspensions and MacPherson strut suspensions. Once removed, the modified strut is serviced in much the same manner as a conventional strut. The spring on the MacPherson strut, however, is serviced differently from a spring on a conventional suspension.

B. Procedures for removing the spring, the ball joint, and the control arm from a modified suspension strut are much like the procedures for removing the spring, the ball joint, and the control arm from a short and long arm suspension system. Consult the proper service manual when working with these systems.

AS1-L1-UXI

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR INSPECTING, REMOVING, AND INSTALLING MACPHERSON STRUT ASSEMBLIES

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for inspecting the MacPherson strut assembly prior to removal.
3. Develop a written procedure for removing the MacPherson strut assembly.
4. Develop a written procedure for installing the MacPherson strut assembly. Make sure the procedure includes all the necessary torque specifications.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REPLACING MACPHERSON STRUT DAMPENERS, SPRINGS, AND MOUNTS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for disassembling the MacPherson strut assembly.
3. Develop a written procedure for reassembling the MacPherson strut assembly.
4. Develop a written procedure for replacing the dampener cartridge, if applicable.

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING, REMOVING, AND INSTALLING MACPHERSON STRUT ASSEMBLIES

Equipment:

Torque wrench
Hand tools
Hoist
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Place the vehicle securely on safety stands or lift it with hoist placed under the frame. ___ ___ ___ ___

   (**CAUTION:** Use the proper equipment and observe the proper safety procedures when lifting the vehicle.)

3. Complete AS1-L1-UXI. Following the procedure developed in item 2 of AS1-L1-UXI, inspect the strut condition. Record the inspection results below. ___ ___ ___ ___

   Dampener OK_____ NOT OK_____
   Spring condition OK_____ NOT OK_____
   Strut mount OK_____ NOT OK_____
   Strut OK_____ NOT OK_____
   Jounce bumper OK_____ NOT OK_____

   If any of the above items were marked "NOT OK," recommend appropriate repair procedures.

4. Following the procedure developed in item 3 of AS1-L1-UXI, remove the MacPherson strut assembly. ___ ___ ___ ___

   a. If eccentric washers are used at the lower strut mount, be sure to mark their positions before removing them.

   b. If any brake hoses are disconnected, plug the openings to prevent contaminants from entering the brake system.

5. Using the procedure developed in item 4 of AS1-L1-UXI, install the strut assembly. ____

   a. Align marks made on eccentric washer if applicable.

   b. Tighten all fasteners to the specified torque.

   c. Reconnect the brake line (if it was disconnected during strut removal) and bleed the brakes.

      (NOTE: See instructor for information on brake bleeding.)

   d. Check and reset all alignment angles as necessary.

   e. Lower vehicle.

      (NOTE: See instructor for information on alignment. This procedure will be covered in a later unit.)

   Average of above evaluations* ____

   (*This average is a partial evaluation for Competencies S6 and T3. Final evaluations for S6 and T3 will be made at the end of JS2-L1-UXI.)

JS2-L1-UXI

MODULE: STEERING AND SUSPENSION SYSTEMS

REPLACING MACPHERSON STRUT DAMPENERS, SPRINGS, AND MOUNTS

Equipment:

Hand tools
MacPherson strut spring compressor
Torque wrench
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Place the vehicle securely on safety stands or lift it with a hoist placed under the frame. ___ ___ ___ ___

   (**CAUTION:** Use the proper equipment and observe the proper safety precautions when lifting the vehicle.)

3. Remove the strut assembly from the vehicle, if required. ___ ___ ___ ___

   (NOTE: For this procedure, refer to JS1-L1-UXI.)

4. Complete AS2-L1-UXI. Following the procedure developed in item 2 of AS2-L1-UXI, disassemble the strut assembly. ___ ___ ___ ___

   (**CAUTION:** Use only spring compressors that are approved for MacPherson strut service. Make certain the compressor is securely installed on the compressed spring before the upper piston rod nut is removed.)

5. Inspect the strut components and record the results below. ___ ___ ___ ___

   Strut mount (rubber mount and bearing) OK____ NOT OK____
   Spring OK____ NOT OK____
   Dampener leakage OK____ NOT OK____
   Jounce bumper OK____ NOT OK____

   If any of the above items were marked "NOT OK," describe the problem and recommend appropriate repair procedures.

6. Bench test the dampener and record the results. ____

7. If the strut is equipped with a replaceable dampener cartridge, complete item 3 of AS2-L1-UXI. Following the procedure developed in item 3 of AS2-L1-UXI, remove the strut dampener and install a cartridge. If working with a sealed strut, skip this procedure and go to item 9 below. ____

8. Following the procedure developed in item 4 of AS2-L1-UXI, reassemble the strut assembly. ____

   a. Replace all worn or missing parts as directed by the instructor.

   b. Be certain the spring is properly aligned and seated in the spring mounts as shown in the service manual.

9. Install the strut assembly on the vehicle if required. For this procedure, refer to JS1-L1-UXI. ____

Average of above evaluations* ____

(*This average is a partial evaluation for Competencies S6 and T3. Final evaluations for S6 and T3 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency S6 by averaging the evaluations of JS2-L1-UIX, JS3-L1-UIX, JS3-L1-UX, JS5-L2-UX, JS1-L1-UXI, and JS2-L1-UXI. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS2-L1-UIX	___	___	___	___
JS3-L1-UIX	___	___	___	___
JS3-L1-UX	___	___	___	___
JS5-L2-UX	___	___	___	___
JS1-L1-UXI	___	___	___	___
JS2-L1-UXI	___	___	___	___
Final evaluation for Competency S6	___	___	___	___

II. Determine the student's final evaluation for Competency T3 by averaging the evaluations of JS1-L1-UXI, and JS2-L1-UXI. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L1-UXI	___	___	___	___
JS2-L1-UXI	___	___	___	___
Final evaluation for Competency T3	___	___	___	___

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XI: MACPHERSON STRUT SUSPENSION SERVICE

UNIT XI TEST

PART I. DIAGNOSING MACPHERSON STRUT SUSPENSIONS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. A MacPherson strut suspension uses only a lower ball joint.

____ 2. On MacPherson strut suspensions, strut rods are used to control the strut.

____ 3. Stabilizer bars are used on MacPherson strut suspension systems.

____ 4. The jounce test is often the best test to test coil springs on MacPherson strut suspension systems.

____ 5. On a MacPherson strut, a dampener functions in much the same way as a shock.

SECTION B. **Select the best answer from the five choices listed.**

____ 6. Binding of the steering can be caused by a

a. defective strut cartridge.
b. defective upper strut mount bearing.
c. defective lower ball joint.
d. loose control arm spacer.
e. loose spring mount.

____ 7. Strut mounts should be inspected for

a. loose bearings.
b. smooth operation of their bearings.
c. damaged jounce bumpers.
d. damaged dust boots.
e. all of the above.

____ 8. Strut housings should be inspected for

a. signs of physical damage.
b. spring binding.
c. ball joint wear.
d. control arm connection.
e. none of the above.

____ 9. A MacPherson strut spring is a type of

- a. leaf spring.
- b. coil spring.
- c. torsion bar spring.
- d. mono spring.
- e. double spring.

(NOTE: The student must obtain a minimum score of ____ on Part I of the Unit XI Test in order to receive an evaluation for Competency S5.)

PART II. INSPECTING MACPHERSON STRUT ASSEMBLIES

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 10. No special tools are needed to repair MacPherson struts.

____ 11. MacPherson struts contain the shock within the assembly.

____ 12. A spring should never be removed from a strut without a spring compressor.

____ 13. Repairable struts have a removable dampener assembly, which fits in the strut housing.

____ 14. Wheel alignment should be checked after strut replacement.

SECTION B. **Select the best answer from the five choices listed.**

____ 15. Before removing the MacPherson strut, the technician should

- a. unload the suspension.
- b. mark the strut for reassembly.
- c. remove the wheel and tire assembly.
- d. remove the brake line if necessary.
- e. do all of the above.

____ 16. When disassembling a MacPherson strut, the technician must use a special

- a. spring compressor.
- b. hammer.
- c. pickle fork.
- d. taper breaking rod.
- e. voltmeter.

____ 17. The technician should never disassemble a strut without first relieving the

- a. oil pressure.
- b. gas pressure.
- c. dampener pressure.
- d. spring pressure.
- e. suspension pressure.

____ 18. The term "repairable-type strut" means that the strut can be fixed by

- a. lubricating all its components.
- b. adding a new spring.
- c. repairing the dampener.
- d. installing a new boot.
- e. welding any damaged components.

____ 19. Service procedures for modified MacPherson struts include service procedures used for struts and

- a. straight axles.
- b. torsion bars.
- c. conventional (SLA) systems.
- d. conventional steering systems.
- e. rack and pinion steering systems.

____ 20. When checking a strut, the technician should

- a. jounce the vehicle.
- b. look for excessive oil leakage.
- c. listen for unusual noises.
- d. check for binding of the strut.
- e. do all of the above.

(NOTE: The student must obtain a minimum score of ____ on Part II of the Unit XI Test in order to receive an evaluation for Competencies S6 and T3.)

ANSWERS TO UNIT XI TEST

1.	t	11.	t
2.	f	12.	t
3.	t	13.	t
4.	f	14.	t
5.	t	15.	e
6.	b	16.	a
7.	e	17.	d
8.	a	18.	c
9.	b	19.	c
10.	f	20.	e

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XII: WHEEL BEARING AND SPINDLE SERVICE

UNIT OBJECTIVE

After completing this unit, the student should be able to service and replace wheel bearings and spindles. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify the procedures for maintaining serviceable wheel bearings (Competencies S3 and T1, Part I of Unit XII Test).

II. Identify the procedures for servicing and adjusting wheel bearings (Competencies S3 and T1, Part I of the Unit XII Test).

III. Identify the procedures for inspecting and servicing nonsealed wheel bearings (Competencies S3 and T1, Part I of the Unit XII Test).

IV. Identify the procedures for adjusting nonsealed wheel bearings (Competencies S3 and T1, Part I of the Unit XII Test).

V. Identify the procedures for inspecting and servicing sealed wheel bearings (Competencies S3 and T1, Part I of the Unit XII Test).

VI. Identify the procedures for inspecting and replacing the spindle (Competency S3, Part II of the Unit XII Test).

VII. Demonstrate the ability to:

  a. Service nonsealed tapered roller wheel bearings (Competencies S3 and T1, JS1-L1-UXII).

  b. Remove and install sealed front-wheel-drive wheel bearings (Competencies S3 and T1, JS2-L1-UXII).

  c. Remove and install a wheel spindle on a long and short arm suspension (Competencies S3 and T1, JS3-L1-UXII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D035 and D051.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XII: WHEEL BEARING AND SPINDLE SERVICE

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plan

  1. Lesson 1: WHEEL BEARING AND SPINDLE MAINTENANCE

    a. Information outline

    b. Assignment sheets

      AS1-L1-UXII: Procedures for Removing, Inspecting, Repacking, and Replacing Nonsealed Tapered Roller Wheel Bearings
      AS2-L1-UXII: Procedures for Replacing Sealed Wheel Bearings on Front-Wheel-Drive Vehicles
      AS3-L1-UXII: Procedures for Removing and Installing a Wheel Spindle on a Short and Long Arm Suspension

    c. Job sheets

      JS1-L1-UXII: Servicing Nonsealed Tapered Roller Wheel Bearings
      JS2-L1-UXII: Removing and Installing Sealed Wheel Bearings: Front-Wheel-Drive Vehicles
      JS3-L1-UXII: Removing and Installing a Wheel Spindle on Long and Short Arm Suspensions

E. Unit test

F. Answers to unit test

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Chrysler Corporation. Service Manual, Rear Wheel Drive 1985 Passenger Cars Chrysler Corporation. 1984.

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Moog Automotive Inc. Moog Front End Service Manual, Inspection and Service Procedures. St. Louis, Missouri: Moog Automotive Inc. 1986.

Toboldt, William K. and Johnson, Larry. Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair. South Holland, Illinois: The Goodheart-Willcox Company, Inc. 1981.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L1-UXII in conjunction with JS1-L1-UXII; AS2-L1-UXII in conjunction with JS2-L1-UXII; and AS3-L1-UXII in conjunction with JS3-L1-UXII.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XII: WHEEL BEARING AND SPINDLE SERVICE

LESSON 1: WHEEL BEARING AND SPINDLE MAINTENANCE

I. Wheel bearings are used on the front wheels of most rear-wheel-drive vehicles, on the rear wheels of many front-wheel-drive vehicles, and on the front wheels of some front-wheel-drive vehicles.

  A. Bearing maintenance includes the tasks listed below.

    1. Disassembling the bearings

    2. Cleaning the bearings (removing all old lubricant and contaminants)

    3. Inspecting the bearings for defects

    4. Replacing grease seals

    5. Replacing defective bearings

    6. Repacking the bearings with the specified lubricant

    7. Reinstalling and adjusting the bearings

II. Wheel bearing service and adjustment

  A. The vehicle must be lifted when the wheel bearings are being serviced. Lift the vehicle with a jack and support the vehicle with jack stands.

  (**CAUTION:** If the vehicle is raised with a jack for wheel bearing service, make sure that it is supported by jack stands or safety stands.)

  B. Special tools are available for removing the hub cap. Wheel bearing packers can also be used to force grease into the wheel bearing. For most wheel bearing service, however, a torque wrench and common hand tools are sufficient.

  C. There are many brands of quality wheel bearing lubricants on the market. Improper lubricants may break down when exposed to heat, stiffen when exposed to cold, or simply lack the lubricating capability needed for high-speed driving. Always use a high-quality wheel bearing grease. Wheel bearing grease that is identified as suitable for use in disc brake systems is usually acceptable for all applications.

  D. Some wheel bearings on late-model front-wheel-drive vehicles are not serviceable. Do not attempt to lubricate nonserviceable bearings. When found defective, the entire bearing assembly must be replaced. In some cases, the entire knuckle may also have to be replaced.

  E. All serviceable wheel bearings have scheduled service intervals ranging from 20,000 to 30,000 miles under normal driving conditions.

III. Inspecting and servicing nonsealed wheel bearings

(NOTE: Before servicing a wheel bearing, determine whether the bearing is a sealed or nonsealed bearing. Though most four-wheel-drive vehicles use sealed bearings, the bearings are individually serviceable once they are removed. Consult the proper service manual for inspecting and replacing these bearings.)

A. Procedure for inspecting nonsealed wheel bearings

1. Lift and safely support the vehicle.

2. Spin the wheel. The wheel should turn freely without binding or making any noise.

3. Grasp the wheel by the top and bottom of the tire and try to move it in and out. The wheel should move slightly (.001 to.005 inch as measured by a dial indicator on the drum or rotor).

4. If spinning the wheel and moving the tire in and out reveals no problems, then no other inspection is required. If, however, the bearings are not noisy but slightly loose, adjustment may be necessary (adjustment will be discussed below). If the bearings are noisy or excessively loose or tight, then service will be required.

B. Procedure for servicing nonsealed wheel bearings

1. Safely lift and secure the vehicle.

2. Remove the wheel.

3. Encapsulate the brake assembly and remove all asbestos dust.

   (**CAUTION:** Do not allow brake dust to escape into the environment. Brake dust contains asbestos which can cause cancer if exhaled.)

4. Remove the brake caliper or drum.

   a. If the caliper is not to be serviced at this time, the hydraulic hose may be left connected.

   b. If the hydraulic hose is left connected, care should be taken to prevent the caliper from hanging on the hose.

5. Examine the hub assembly. Look for a dust cap at the center of the hub.

6. Remove the dust cap.

7. Remove the cotter pin from the spindle nut.

8. Remove the spindle nut.

   Carefully remove the washer and the outer wheel bearing from the center of the wheel.

   (**CAUTION:** Be careful not to drop the bearing.)

9. Slide the rotor off the spindle.

   (CAUTION: Do not place fingers on the friction surface of the rotor. Do not allow the rotor to drag heavily across the spindle threads.)

10. Using a brass or wooden drift, reach through the hub and tap the inner grease seal out of the hub.

11. Remove the inner wheel bearing.

12. Using a clean shop towel, wipe the grease out of the hub. Avoid getting grease on the friction surfaces of the rotor.

    (NOTE: If the rotor is in two pieces, work on the hubs with the friction disk removed.)

    (CAUTION: Keep all wheel bearings in sets, and return them to the spindle from which they were taken. Do not replace defective wheel bearings with used wheel bearings.)

13. Thoroughly wash the wheel bearings (and all of the other parts removed with them) in solvent. Using compressed air, blow all old grease out of the bearing. Make sure all grease is removed from the inside of the bearing. Rewash the bearings and accompanying parts.

    (CAUTION: Do not allow the bearing to spin on the finger or fingers while blowing the bearing dry; doing so may result in personal injury.)

14. Examine each bearing carefully and note any imperfections such as chips, pits, scratches, etc. Also examine bearing for discoloration, which indicates overheating. If any problems are found, replace the bearing.

    (NOTE: Always replace the bearing and its race if there is any doubt about its condition.)

15. Repack each bearing with fresh grease, pushing it into the larger side of the bearing assembly by hand until it is forced out of the smaller side of the bearing.

    (NOTE: Make sure bearings are repacked with a grease designed to withstand the high temperatures and extreme pressures to which it will be exposed.)

16. Place the equivalent of 3 or 4 table spoons of grease in the center of the hub.

17. Install the inner wheel bearing and a new grease seal.

18. Carefully slide the hub assembly onto the spindle.

19. Install the outer wheel bearing, washer, and spindle nut.

    (CAUTION: If solvent or grease gets on the drum or disc friction surfaces, the surfaces should be cleaned with an acceptable brake cleaning solvent.)

20. Adjust the bearing. Procedures for bearing adjustment are described below.

21. Reassemble the remaining brake and wheel assembly components.

IV. Adjusting nonsealed wheel bearings

(NOTE: Adjustment procedures for nonsealed bearings differ greatly from adjustment procedurse for sealed bearings. What is sometimes called an adjustment procedure for sealed bearings is actually a tightening procedure.)

A. Procedure for adjusting nonsealed bearings (typical rear-wheel-drive wheel bearing arrangement)

1. Safely lift and secure vehicle.

2. Remove wheel cover (hub cap).

3. Remove dust cap from wheel hub.

4. Remove cotter pin and/or nut locking device.

5. Tighten the spindle nut to manufacturer's specifications.

6. Loosen the lock nut to manufacturer's specifications.

7. Using a dial indicator, check the play in the bearings at the rotor or hub.

8. Reinstall a new cotter pin or nut holding device and then reinstall the dust cover.

9. Reassemble the remaining components of the brake and wheel assemblies.

B. Sealed bearings are not really adjusted but merely tightened. Most four-wheel-drive or front-wheel-drive vehicles have sealed bearings. If a sealed bearing makes noise or does not turn smoothly, the entire unit must be disassembled so the bearings can be evaluated and, if necessary, replaced. If sealed bearings are replaced, the new bearings must be adjusted (or tightened) according to manufacturer's specifications. Procedures for adjusting (tightening) sealed bearings vary from vehicle to vehicle. The technician must, therefore, consult the proper repair manual for the correct procedure.

(NOTE: On some Chrysler and foreign front-wheel-drive vehicles, use bearings that cannot be adjusted even though they are not sealed. If these bearings make noise or fail to turn smoothly, the entire unit must be disassembled so the bearings can be evaluated and packed.)

V. Inspecting and servicing sealed bearings

A. Procedure for inspecting sealed wheel bearings

1. Safely lift and secure the vehicle.

2. Spin the wheel. The wheel should turn freely without binding or making any noise.

3. Grasp the wheel by the top and bottom of the tire and try to move it in and out. The wheel should move slightly (.001 to.005 inch as measured by a caliper on the drum or rotor).

4. If spinning the wheel and moving the tire in and out reveals no problems, then no other inspection is required. If the bearings are noisy or excessively loose or tight, then the bearing will probably have to be replaced.

B. Procedures for removing and replacing sealed wheel bearings vary greatly. Refer to the proper service manual for the procedure that applies to the vehicle to be serviced.

(NOTE: Some front-wheel-drive vehicles may have wheel bearings that are incorporated into the knuckles. This design requires that the drive axles and bearings be removed from the knuckle. In most of these designs, the bearing must be pressed in and out of the spindle. See proper service manual for procedures regarding the replacement of sealed wheel bearings.)

(NOTE: Most sealed wheel bearings are non-adjustable.)

VI. Inspecting and replacing the spindle

A. Procedure for inspecting spindles

(NOTE: Under normal service, the spindle seldom fails. Damage from an accident or from a failed bearing is the usual cause of spindle failure. However, the technician should always inspect spindles during normal bearing service.)

1. Inspect the grease seal surface for wear or roughness.

2. Inspect the condition of the threads on the end of the spindle.

    a. Rough threads make bearing adjustment difficult. Rough threads can sometimes be repaired with a thread chaser.

    b. If the threads are badly damaged or stripped, the spindle should be replaced.

3. Inspect the surfaces on which the inner bearing cones rest.

    a. The surface should have no burrs or roughness. Minor nicks may be dressed down with a file.

    b. If major damage is found, the spindle should be replaced. Major damage may prevent the bearing from running true.

    c. The inner cones should slide smoothly over the spindle and yet have a snug fit. If cones are known to be good but still fit loosely, the spindle must be replaced.

B. Procedure for removing the spindle (a spindle that is integral with the steering knuckle)

(NOTE: The below procedure is general in nature. Refer to the proper service manual for the precise procedure for the vehicle to be serviced.)

1. Safely raise and support the vehicle under its frame.

    a. If the spring is on the upper control arm, place a suitable spacer (such as a block of wood) between the upper control arm and the frame before raising the vehicle.

   b. If the spring is on the lower control arm, place a floor jack under the lower control arm at the spring seat. Do not apply pressure to the jack before loosening the ball joint. The spring pressure will help break the ball joint tapers.

2. Remove wheel and tire assembly.

3. Remove the brake caliper and hub and rotor assembly.

4. Remove the brake rotor shield from the steering knuckle.

5. Remove cotter pin and nut. Next, using a suitable taper breaking tool, remove the tie rod end from the knuckle.

6. Remove the cotter pin from the upper and lower ball joints.

7. Loosen the upper ball joint nut one or two turns, but do not remove the nut.

   (**CAUTION:** It is very important not to remove the nut before breaking the taper. The upper and lower ball joint nuts must be in place when the tapers are broken or the spring force will be unleashed.)

   a. Using a taper breaking tool, break the taper between the knuckle and the upper ball joint.

   b. It sometimes helps to rap the knuckle sharply with a hammer at the ball joint while pressure is being applied with the taper breaker.

8. Loosen the lower ball joint nut one or two turns, but do not remove the nut.

   (**CAUTION:** The ball joint nut should not be removed before spring pressure is applied to the spring seat. Failure to support the spring seat before removing the ball joint nut could cause serious injury to the technician.)

   a. Using a taper breaking tool, break the taper between the knuckle and lower the ball joint.

   b. As with the upper ball joint, a rap with a hammer can be helpful when removing the lower ball joint.

9. Raise the floor jack just enough to support the lower control arm.

   (**CAUTION:** The jack must always remain under the lower control arm while the ball joint is disconnected.)

10. Remove the upper and lower control arm nuts.

11. Remove the spindle/knuckle.

C. Procedures for replacing a spindle (a spindle that is integral with the knuckle)

   1. Thoroughly clean the tapered holes in the knuckle and ball joint studs.

   2. Install the knuckle in the upper and lower ball joint studs.

   a. Install and tighten the upper and lower ball joint nuts to the specified torque.

   b. Install the cotter pins in both the upper and lower ball joint studs. If necessary, tighten the nuts further to install the cotter pins; never loosen the nuts to align a cotter pin hole.

3. Install the tie rod end. Tighten the nut to the specified torque and install the cotter pin.

4. Install the brake shield and tighten the fasteners to the specified torque.

5. Clean, inspect, and repack the wheel bearings.

   a. Install a new grease seal.

   b. Replace any defective bearings.

6. Install hub and [illegible]

   a. Adjust the wheel bearings according to the manufacturer's specifications.

   b. Install a new cotter pin.

7. Install the brake caliper and tighten fasteners to the specified torque.

8. Install the wheel and tire assembly. Tighten the wheel nuts to the specified torque.

9. Lower the vehicle.

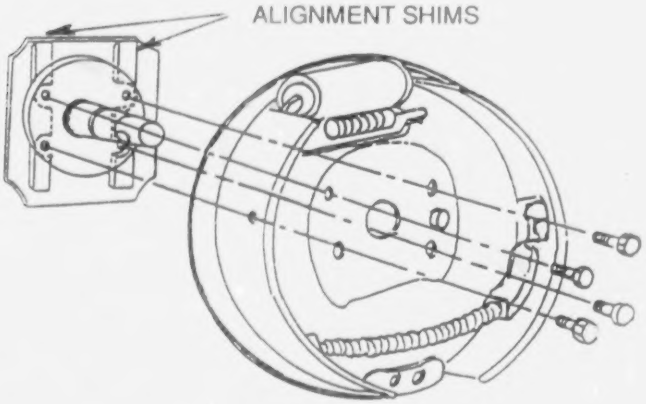
10. Apply brakes to seat pads against the rotor before moving the vehicle.

D. Procedure for removing a spindle (a spindle that is separate from the knuckle)

   1. On some vehicles, particularly four-wheel-drive vehicles, the spindle is separate from the steering knuckle. The rear wheels on front-wheel-drive vehicles also have no steering knuckles on the rear but have removable spindles.

   2. To remove spindles that are not integral with the steering knuckle, merely remove the bolts holding the spindle to the knuckle or axle. The bolts can be accessed after removing the wheel and tire, the brake caliper, the hub and rotor, or brake drum and backing plate.

3. On some vehicles, wheel alignment is adjusted in part by shims placed behind the spindles. If shims are used to align the spindles, note the shims' position and be sure they are reinstalled in the same manner.



MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REMOVING, INSPECTING, REPACKING, AND REPLACING NONSEALED TAPERED ROLLER WHEEL BEARINGS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual and the information provided in this unit.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing and installing the wheel bearings.
3. Develop a written procedure for cleaning and inspecting the wheel bearings.
4. Develop a written procedure for repacking and adjusting the wheel bearings. Make sure the procedure includes specifications for adjusting the bearings. Also make sure the procedure identifies the type of lubricant recommended for the bearings.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REPLACING SEALED WHEEL BEARINGS ON FRONT-WHEEL-DRIVE VEHICLES

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing and reinstalling the wheel bearings. Make sure the procedure includes all necessary torque specifications.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REMOVING AND INSTALLING A WHEEL SPINDLE ON A SHORT AND LONG ARM SUSPENSION

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing and installing a wheel spindle. Make sure the procedure includes all necessary specifications.

MODULE: STEERING AND SUSPENSION SYSTEMS

SERVICING NONSEALED TAPERED ROLLER WHEEL BEARINGS

Equipment:

Hand tools
Bearing cone drivers
Dial indicator
Seal driver
Hoist
Safety glasses

Procedure: Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Place the vehicle securely on safety stands or lift it with hoist. ___ ___ ___ ___

   (**CAUTION:** Be sure to use proper equipment and observe all safety rules when lifting a vehicle.)

3. Complete AS1-L1-UXII. Following the procedure developed in item 2 of AS1-L1-UXII, remove the front wheel bearings from the vehicle. Be sure to wipe excessive grease from the bearings, hub, and spindle before cleaning the bearings. ___ ___ ___ ___

4. Following the procedure developed in item 3 of AS1-L1-UXII, clean and inspect the bearings, hub, and spindle. Use the check list below to note any problems. ___ ___ ___ ___

   spindle condition OK_____ NOT OK_____
   bearing cones OK_____ NOT OK_____
   bearing cages OK_____ NOT OK_____
   bearing rollers OK_____ NOT OK_____
   hub condition OK_____ NOT OK_____

   If any of the above items were marked "NOT OK," describe the problem and suggest procedures for correcting it.

   (**CAUTION:** Do not use compressed air to spin the bearings; doing so may cause the rollers to fly out of the bearing and strike people who may be standing nearby. Allow the cones to air dry.)

5. Following the procedure developed in items 3 and 4 of AS1-L1-UXII, repack, install, and adjust the wheel bearings. Replace any damaged or missing parts as directed by the instructor. Lower the vehicle when reinstallation is completed. — — — —

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competencies S3 and T1. Final evaluation for S3 will be made at the end of JS3-L1-UXII. Final evaluation for T1 will be made at the end of JS5-L2-UXIV.)

JS2-L1-UXII

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING SEALED WHEEL BEARINGS: FRONT-WHEEL-DRIVE VEHICLES

Equipment:

Hand tools
Hoist
Special tools as needed
Safety glasses

Procedure:

	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet	___ ___ ___ ___
2. Place the vehicle securely on safety stands or lift it with hoist. (**CAUTION:** Be sure to use proper equipment and observe all safety rules when lifting a vehicle.)	___ ___ ___ ___
3. Complete AS2-L1-UXII. Following the procedure developed in item 2 of AS2-L1-UXII, remove the wheel bearing from the vehicle.	___ ___ ___ ___
4. Clean and inspect the steering knuckle. Record any defects found and suggest procedures to correct them.	___ ___ ___ ___
5. Following the procedure developed in item 2 of AS2-L1-UXII, install the wheel bearing in the vehicle. Tighten all fasteners to the specified torque and lower the vehicle when installation is complete.	___ ___ ___ ___
Average of above evaluations*	___ ___ ___ ___

(*This average is a partial evaluation for Competencies S3 and T1. Final evaluation for S3 will be made at the end of JS3-L1-UXII. Final evaluation for T1 will be made at the end of JS5-L2-UXIV.)

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING A WHEEL SPINDLE ON LONG AND SHORT ARM SUSPENSIONS

Equipment:

Hand tools
Hoist
Floor jack
Ball joint taper breaker
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Place the vehicle securely on safety stands or lift it with a hoist placed under the frame. ___ ___ ___ ___

   (**CAUTION:** Be sure to use proper equipment and observe all safety rules when lifting a vehicle.)

3. Complete AS3-L1-UXII. Following the procedure developed in item 2 of AS3-L1-UXII, remove the spindle from the vehicle. ___ ___ ___ ___

   (**CAUTION:** Retain the coil spring by placing a floor jack under the lower control arm. Keep the jack under the lower control arm at all times .)

4. Following the procedure developed in item 2 of AS3-L1-UXII, install the spindle on the vehicle. Tighten all fasteners to specified torque and lower the vehicle when reinstallation is completed. ___ ___ ___ ___

   (NOTE: Be sure to inspect and repack wheel bearings before installing the spindle. Refer to JS1-L1-UXII for this procedure.)

Average of above evaluations* ___ ___ ___ ___

(*This average is a partial evaluation for Competencies S3 and T1. Final evaluation for S3 will be made at the end of this job sheet. Final evaluation for T1 will be made at the end of JS5-L2-UXIV.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency S3 by averaging the evaluations of JS1-L1-UXII, JS2-L1-UXII, and JS3-L1-UXII. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L1-UXII	___	___	___	___
JS2-L1-UXII	___	___	___	___
JS3-L1-UXII	___	___	___	___
Final evaluation for Competency S3	___	___	___	___

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XII: WHEEL BEARING AND SPINDLE SERVICE

UNIT XII TEST

PART I. DIAGNOSING AND REPAIRING WHEEL BEARINGS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. All wheel bearings can be repacked.

____ 2. Disc wheel bearing grease can be used to pack all types of wheel bearings.

____ 3. Bearing maintenance includes cleaning the bearings.

____ 4. Wheel bearings should be serviced every 40,000 miles.

____ 5. Grease seals should be replaced when wheel bearings are packed.

____ 6. A technician should use a dial indicator to check bearing adjustment.

____ 7. The brakes should usually be encapsulated when wheel bearings are repaired.

____ 8. Bearing end play should be adjusted to the manufacturer's specifications.

____ 9. After being cleaned with solvent, wheel bearings should be dried with a blow gun.

____ 10. If grease gets on brake surfaces during bearing packing, the brakes should be cleaned with solvent.

____ 11. Wheel alignment should be checked after wheel bearing replacement.

(NOTE: The student must obtain a minimum score of ____ on Part I of the Unit XII Test in order to receive an evaluation for Competencies S3 and T1.)

PART II. SERVICING SPINDLES

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 12. A tap is used to repair spindle threads.

____ 13. Under normal service, a spindle seldom fails.

____ 14. When replacing a front spindle that is integral with the steering knuckle, the technician may be seriously injured if he or she unleashes spring pressure at the wrong time.

____ 15. Shims are used to align the rear spindles on some four-wheel-drive vehicles.

____ 16. When changing the spindle, the technician should be careful not to unleash the spring.

____ 17. A bearing of good quality fits snugly over the spindle.

____ 18. Spindles should be inspected during wheel bearing service.

____ 19. In some cases, the ball joint will need to be removed from the spindle before the spindle can be replaced.

____ 20. Procedures for replacing spindles vary little from vehicle model to vehicle model.

(NOTE: The student must obtain a minimum score of ____ on Part II of the Unit XII Test in order to receive an evaluation for Competency S3.)

ANSWERS TO UNIT XII TEST

1. f
2. t
3. t
4. f
5. t
6. t
7. t
8. t
9. t
10. f
11. f
12 f
13. t
14. t
15. t
16. f
17. f
18. t
19. t
20. f

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIII: THE DESIGN AND OPERATING PRINCIPLES OF THE REAR SUSPENSION SYSTEM

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the components and operating principles of various types of rear suspension systems and diagnose and replace worn rear suspension components. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the basic characteristics of rear suspension systems (Competency T1, Part I of Unit XIII Test).

II. Identify the basic characteristics of leaf spring rear suspension systems (Competency T1, Part I of Unit XIII Test).

III. Identify the basic characteristics of rear-wheel-drive coil spring rear suspension systems (Competency T1, Part I of Unit XIII Test).

IV. Identify the basic characteristics of trailing arm rear suspension systems(Competency T1, Part I of Unit XIII Test).

V. Identify the basic characteristics of semi-independent rear suspension systems (Competency T1, Part I of Unit XIII Test).

VI. Identify the basic characteristics of the MacPherson strut rear suspension systems (Competency T1, Part I of Unit XIII Test).

Lesson 2.

I. Identify the procedures for inspecting and replacing leaf springs (Competency T2, Part II of the Unit XIII Test).

II. Identify the procedures for inspecting and replacing coil springs (Competency T1, Part I of the Unit XIII Test).

III. Identify the procedures for inspecting and replacing rear suspension control arms (Competency T4, Part III of the Unit XIII Test).

IV. Identify the procedures for replacing rear shock absorbers (Competency T2, Part II of the Unit XIII Test).

V. Demonstrate the ability to:

  a. Inspect and replace leaf springs (Competency T2, JS1-L2-UXIII).

  b. Inspect and replace rear coil springs (Competency T1, JS2-L2-UXIII).

c. Inspect and replace rear suspension control arms and bushings (Competency T4, JS3-L2-UXIII).

d. Inspect and replace rear suspension shock absorbers (Competency T2, JS4-L2-UXIII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D043-D045 and D049.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIII: THE DESIGN AND OPERATING PRINCIPLES OF THE REAR SUSPENSION SYSTEM

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

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Lesson 1: REAR SUSPENSION SYSTEM DESIGN

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  AS1-L1-UXIII: Rear Suspension System Design

Lesson 2: REAR SUSPENSION SYSTEM SERVICE

- a. Information outline
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  AS1-L2-UXIII: Procedures for Inspecting and Replacing Rear Leaf Springs
  AS2-L2-UXIII: Procedures for Replacing Rear Suspension Coil Springs and Insulators
  AS3-L2-UXIII: Procedures for Replacing Rear Suspension Control Arms and Bushings

- c. Job sheets

  JS1-L2-UXIII: Inspecting and Replacing Rear Leaf Springs
  JS2-L2-UXIII: Inspecting and Replacing Rear Coil Springs and Insulators
  JS3-L2-UXIII: Inspecting and Replacing Rear Suspension Control Arms and Bushings
  JS4-L2-UXIII: Inspecting and Replacing Rear Suspension Shock Absorbers

E. Unit test

F. Answers to unit test

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L1-UXIII before taking the Unit XIII Test. Students should do AS1-L2-UXIII in conjunction with JS1-L2-UXIII; AS2-L2-UXIII in conjunction with JS2-L2-UXIII; and AS3-L2-UXIII in conjunction with JS3-L2-UXIII.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIII: THE DESIGN AND OPERATING PRINCIPLES OF THE REAR SUSPENSION SYSTEM

LESSON 1: REAR SUSPENSION SYSTEM DESIGN

I. Rear suspension systems use many of the same components as front suspension systems. There are several different types of rear suspension designs, all of which provide a stable ride.

II. Leaf spring rear suspensions

A. Rear-wheel-drive leaf spring suspension

1. Rear-wheel-drive leaf spring suspensions are equipped with single or multi-leaf springs at each end of the rear axle. These springs are normally attached to the vehicle at the three points listed below.

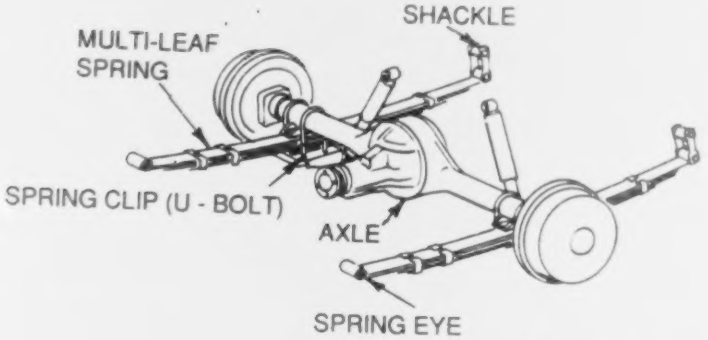
a. The front of the spring connects to a spring hanger on the vehicle frame. The attachment is made via a rubber bushing in the spring eye.

b. The middle of the spring is attached to the axle via U-bolts.

c. The rear of the spring is attached to the vehicle frame by a shackle, which allows the spring to change length as the wheels roll over rough spots in the road surface.

2. Rear-wheel-drive leaf spring suspensions normally use no control arms. The springs maintain the position of the axle assembly.

3. In order to dampen spring movement, rear-wheel-drive leaf spring suspensions have shock absorbers mounted between the axle housing and the vehicle frame at each wheel.



Courtesy of Moog Automotive, Inc.

4. Some rear-wheel-drive leaf spring suspensions are equipped with a stabilizer bar. The front stabilizer bar enhances vehicle stability during cornering.

B. Front-wheel-drive rear leaf spring suspensions

1. Some front-wheel-drive vehicles use a solid axle rear leaf spring suspension. (A solid rear axle incorporates a bar or tube between the two rear wheels.) Spring connections on these front suspensions are made in much the same way as on rear drive leaf spring suspensions.

2. On front-wheel-drive rear leaf spring suspensions, wheel spindles bolt to each end of the axle. Shock absorbers are mounted from the axle to the vehicle frame to dampen spring movement.

III. Rear-wheel-drive coil spring rear suspensions

A. The rear-wheel-drive coil spring suspension is more complicated than the leaf spring rear suspension. The rear-wheel-drive coil spring suspension requires additional components to maintain axle positioning.

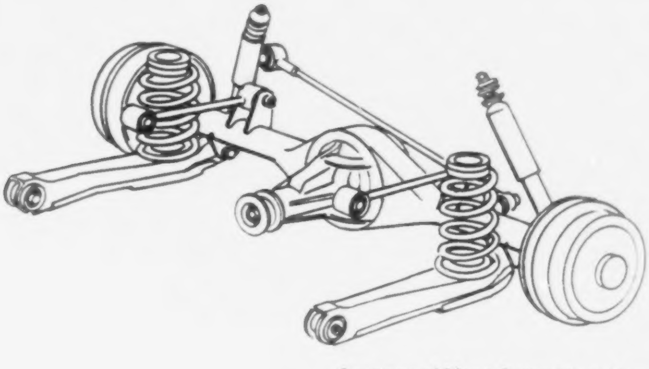
B. The typical rear-wheel-drive coil spring suspension uses a coil spring placed between the lower spring pads (which are welded to each end of the axle housing) and the upper spring pads (which are integral with the vehicle frame).

C. The rear-wheel-drive coil spring suspension uses a lower control arm on each side of the vehicle to control axle movement. The forward ends of the control arm pivot up and down on the vehicle frame via rubber bushings. The rear ends of the control arms are also connected to the axle housing via rubber bushings.

D. The rear-wheel-drive coil spring suspension also uses either one or two upper control arms, which are positioned between the axle housing and the vehicle frame. Rubber mounting bushings provide noise insulation while allowing the upper arms to pivot.

E. Some rear-wheel-drive coil spring suspensions use a track bar, which is a steel bar with rubber bushings mounted on each end. The bar is mounted between the axle housing and the vehicle frame. The track bar controls vehicle lateral movement or side sway.

F. A stabilizer bar is sometimes added to control body roll during cornering. The design and operation of the stabilizer bar are similar to the bars used in front suspension systems.



Courtesy of Moog Automotive, Inc.

IV. Trailing arm rear suspensions

A. The trailing arm rear suspension is used on many front-wheel-drive vehicles. In the trailing arm suspension, an axle beam is attached to the vehicle frame by two steel trailing arms. The trailing arms are welded to the axle and connected to the frame via rubber bushings. As the wheels move up and down, the axle beam is allowed to twist a predetermined amount, therefore providing "semi-independent" suspension action.

B. In most trailing arm rear suspensions, a track bar is used to control lateral axle movement. The track bar is mounted laterally from the axle to the vehicle frame. Rubber bushings at each end of the bar allow up and down movement.

C. Coil springs are mounted on the inboard side of the trailing arms. The lower spring pads are welded to the axle. The upper spring seats are integral with the vehicle frame.

D. In order to control spring movement, shock absorbers are mounted from the axle to the vehicle frame at each wheel.

E. Wheel spindles are bolted to each end of the axle and support the wheels through wheel bearings.

V. Semi-independent rear suspensions

A. Semi-independent rear suspension is another design found on the rear wheels of some front-wheel-drive vehicles. A semi-independent rear suspension consists of two trailing arms, which are interconnected by a lateral beam.

B. The front of the trailing arms on semi-independent rear suspensions is suspended by hanger/bushing arrangements.

C. Coil suspension springs on semi-independent rear suspensions are mounted on shock absorbers in a similar fashion to MacPherson struts.

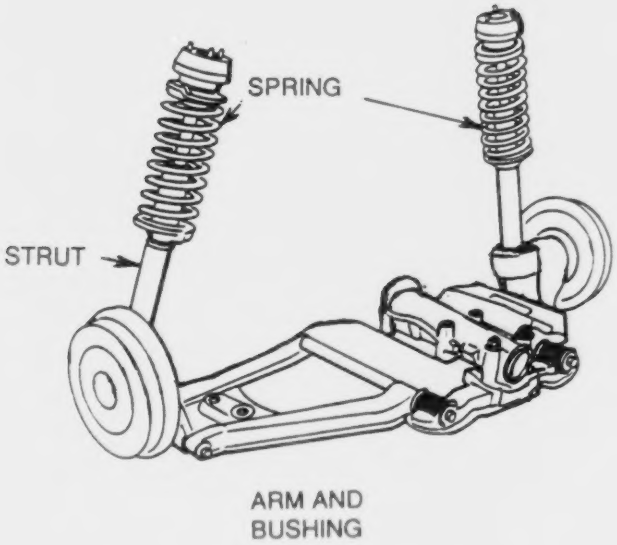
D. Wheel spindles on semi-independent rear suspensions are attached to the rear of the trailing arms.

E. Some models on semi-independent rear suspensions are equipped with a sway bar.

F. When hitting a bump, the spring will compress and the lateral beam will be forced to twist, thus allowing a limited amount of independent suspension action.

G. When the suspension rebounds, the lateral beam will return to its original position.

VI. The MacPherson strut rear suspension is similar to the MacPherson strut front suspension. A MacPherson strut unit is mounted at each rear wheel. A lower control arm is mounted between the vehicle frame and the strut at each rear wheel. The upper strut mount attaches to a reinforced vehicle body. Strut rods are used to minimize forward/rearward movement of the assemblies.



Courtesy of Moog Automotive, Inc.

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MODULE: STEERING AND SUSPENSION SYSTEMS

REAR SUSPENSION SYSTEM DESIGN

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. Which components of the leaf spring rear suspension hold the axle in position?

2. In the leaf spring rear suspension, which component changes the length of the leaf spring as the vehicle travels over a rough surface?

3. On coil spring suspensions, which component is used to control axle positioning?

4. In which type of suspension are the spring and shock absorber contained in a single suspension unit?

5. Which type of rear suspension is used on most front-wheel-drive vehicles?

MODULE: STEERING AND SUSPENSION SYSTEMS

REAR SUSPENSION SYSTEM DESIGN

(ANSWER SHEET)

1. Springs
2. Spring shackles
3. Control arms
4. MacPherson strut
5. Trailing arm rear suspension

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIII: THE DESIGN AND OPERATING PRINCIPLES OF THE REAR SUSPENSION SYSTEM

LESSON 2: REAR SUSPENSION SYSTEM SERVICE

(NOTE: Always replace suspension fasteners with fasteners of the same quality. Replacing a fastener with one of lesser quality could cause suspension failure and lead to loss of vehicle control or major repair expense. To ensure proper retention of suspension components, always tighten fasteners to the manufacturer's torque specifications.)

(NOTE: Never repair suspension parts by heating, quenching, straightening, or welding them. Always replace worn or damaged parts with new ones.)

I. Inspecting and replacing leaf springs

  A. Procedures for visually inspecting a leaf spring suspension system (prior to removal)

    1. Inspect each leaf for cracks or breaks. Broken leaves must be replaced.

       (NOTE: Broken leaf springs will often leave a rust deposit near the crack.)

    2. Inspect the tie bolt for breakage. Broken leaves will slide out of position.

    3. Inspect the condition of the inner leaves.

    4. Inspect the U-bolts for tightness or breakage.

    5. Make sure the rebound clips are in good condition.

    6. Make sure the shackles and bushings are in good condition.

  B. Procedures for removing the leaf spring

    1. Raise the vehicle with a hoist or with a floor jack under the axle housing. Place safety stands under the vehicle frame. Leave hoist under the axle to relieve weight on the springs.

    2. Disconnect the rear shock absorber at the axle housing.

    3. Lower the axle housing, allowing the rear springs to hang free.

    4. Remove U-bolts and spring retainer plate.

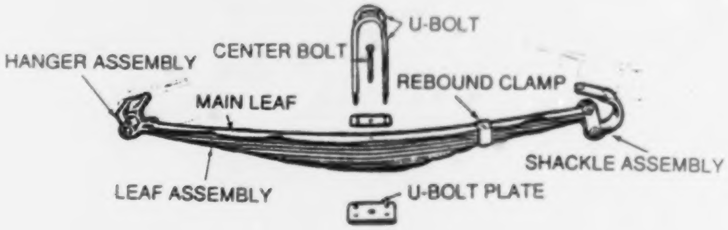
    5. Raise the axle just enough to remove the weight from the spring.

    6. Remove the rear shackle bolts and remove the rear shackle.

    7. Remove the front hanger bolt from the front spring eye and remove the spring.

(**CAUTION:** Leaf springs are very heavy. Have an assistant help to hold and lower the spring assembly from the vehicle. Serious personal injury could result from being struck by a falling spring.)

C. Inspect the leaf spring suspension system after it is removed. Use the same procedure as for inspecting the suspension prior to removal. Bushings, tie bolts, and spring leaves are more easily inspected after the spring is removed.



D. Procedure for installing the leaf spring

1. Place the spring under the axle and install the spring in the front hanger. Tighten fasteners only finger tight.
2. Install the rear of the spring in the shackle and tighten fasteners finger tight.
3. Lower the axle until it rests on the spring and install the U-bolts and spring plate. Tighten U-bolt nuts to specified torque.

   (NOTE: Make sure the center spring bolt goes in the hole in the differential housing spring plate.)

   (NOTE: Do not forget to install the rubber cushion between the spring and the axle housing.)
4. Connect the lower end of the shock to the axle housing plate.
5. Place safety stands under the rear axle and lower the vehicle until it is sitting at approximately normal ride height.
   a. Tighten front spring hanger bolt to specified torque.
   b. Tighten rear shackle bolts to specified torque.
   c. Remove safety stands and lower the vehicle.

E. Procedure for replacing spring bushings

1. If a spring eye bushing is found to be worn, it must be replaced. Bushing replacement is usually done while the spring is removed from the vehicle.
2. A special tool is usually required to press the old bushing out and to press the new one in. The bushings may also be pressed in and out with a shop press and suitable adapters.

II. Inspecting and replacing coil springs

A. As with front suspension coil springs, measuring the ride height gives a good indication of the condition of the spring.

(NOTE: Refer to Unit IX for procedures for measuring ride height.)

B Procedure for visually inspecting coil springs

1. Look for shiny spots on the coils, which are evidence of coil spring clash (i.e. coils hitting one another during jounce). Coil spring jounce may be caused by weak springs, defective shock absorbers, or a combination of both problems.

2. Look for collapsed or broken coils.

C. Procedure for removing a rear coil spring (typical rear drive axle)

1. Raise the vehicle with a hoist or with a floor jack placed under the axle housing. Place safety stands under the frame and place the weight of the vehicle on the safety stands. Do not lower the hoist or jack all the way at this time.

   (NOTE: On some vehicles, the brake line between the frame and axle housing will have to be disconnected to allow enough movement of the axle housing to remove the springs.)

2. Disconnect the lower end of the shock absorbers at the axle housing.

3. Lower the hoist or floor jack and remove the springs and rubber insulators.

   (**CAUTION:** Do not get under the axle assembly as it is lowered.)

   (**CAUTION:** When the jack is lowered, the springs may fall. Be prepared to secure the springs.)

D. Procedure for installing the springs

1. Inspect the condition of the insulators. If they are worn or deteriorated, replace them.

2. Clean the spring seats and remove any dirt or gravel.

3. Tape insulators to the springs to hold them in place, if necessary.

4. Place the springs between the spring seats. The springs should rest on the lower seat.

5. Raise the axle and reconnect the lower shock absorber mountings.

6. Tighten all fasteners to the specified torque.

   (NOTE: If the brake line was disconnected, then reconnect the brake line and bleed the brake system.)

III. Inspecting and replacing rear suspension control arms

- A. Procedure for inspecting the control arm
  - 1. Inspect the arm for bent or broken lower and upper control arms and track bars.
  - 2. Inspect bushings for deterioration and wear. Bolts should be centered in the bushings.
- B. Removing and installing the lower control arm

  (NOTE: If both control arms are to be replaced, remove only one arm at a time to prevent the axle from moving sideways or rolling.)

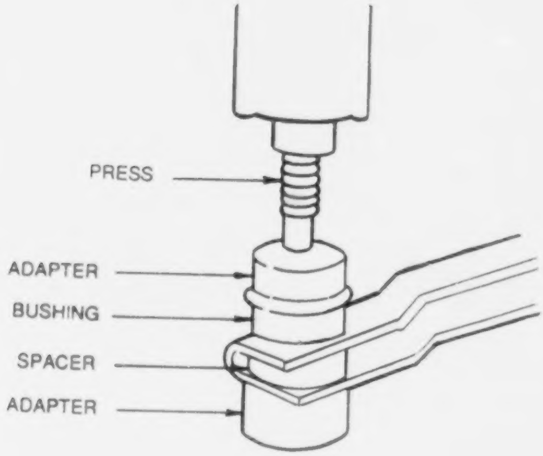
  - 1. Procedure for removing the lower control arm
    - a. Raise the vehicle and support it with a hoist or with safety stands placed under the axle housing.
    - b. Remove the rear arm to the axle housing bracket bolt.
    - c. Remove the front arm to the bracket bolts and remove the lower control arm.
  - 2. Procedure for installing the lower control arm
    - a. To install the lower control arm, merely reverse the removal procedure.
    - b. Tighten all fasteners to the specified torque.
- C. Removing and installing the upper control arm

  (NOTE: If both control arms are to be replaced, remove only one arm at a time to prevent the axle from moving sideways or rolling.)

  - 1. Procedure for removing the upper control arm (rear-wheel-drive axle)
    - a. Raise the vehicle and support it with safety stands placed under the axle housing.
    - b. Place a support under the differential pinion nose.
    - c. Remove the front and rear arm attaching bolts and then remove the arm.
  - 2. Procedure for installing the upper control arm (rear-wheel-drive axle)
    - a. To install the upper control arm, merely reverse the removal procedure.
    - b. Tighten all fasteners to the specified torque.
- D. Control arm bushing replacement
  - 1. The bushings in many control arms may be replaced while the arm is removed from the vehicle.

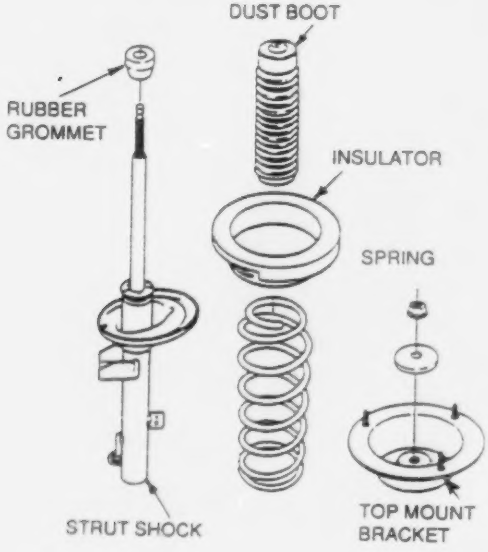
(NOTE: Some bushings cannot be serviced. If nonserviceable bushings are defective, the entire control arm must be replaced.)

2. Using a press and suitable adapters, prsss out the bushing. Be certain to support the inner portion of the arm to prevent it from being crushed.


PRESS
ADAPTER
BUSHING
SPACER
ADAPTER

3. In some suspension systems, the bushings are located on the axle end of the upper arm. The bushings are pressed into a flange on the axle housing instead of the arm.

(NOTE: Rear suspension Macpherson struts are serviced in much the same way as front suspension Macpherson struts. Strut service is covered in Unit XI of this section. When working with a rear MacPherson strut suspension system, consult the appropriate service manual for the specific procedures.)


DUST BOOT
RUBBER GROMMET
INSULATOR
SPRING
STRUT SHOCK
TOP MOUNT BRACKET

IV. Replacing rear shock absorbers

A. Raise the vehicle and support it under the axle housing.

(**CAUTION**: Failure to support the vehicle weight by the axle housing can result in serious injury when the shock is removed and the axle housing drops 4" to 7".)

B. Disconnect the upper shock absorber mounting. On some vehicles, the upper shock absorber mounting is accessed from the inside of the luggage or passenger compartment. Consult the appropriate service manual when removing shock absorbers.

C. Disconnect the lower shock absorber mounting and remove the shock absorber.

(**CAUTION:** If working with gas-charged shocks, do not apply heat or flame to the shock absorber tube during disassembly.)

(NOTE: Once gas-charged shocks are disconnected, they will expand rapidly.)

D. Install the shock absorber in reverse order of disassembly.

1. Bleed air from the shock before installing. Refer to Unit X for this procedure.
2. Tighten all fasteners to specified torque.

E. Procedures for testing rear shock absorbers are the same as for front shock absorbers. Refer to Unit X for the correct procedures.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR INSPECTING AND REPLACING REAR LEAF SPRINGS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the leaf spring.
3. Develop a written procedure for replacing the spring eye bushings.
4. Develop a written procedure for visually inspecting the spring, hangers, shackles, U-bolts, tie bolt, and interleaves.
5. Develop a written procedure for installing the leaf spring. Make sure the procedure includes all necessary torque specifications.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REPLACING REAR SUSPENSION COIL SPRINGS AND INSULATORS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the rear suspension coil spring.
3. Develop a written procedure for installing the rear suspension coil spring. Make sure the procedure includes all necessary torque specifications.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REPLACING REAR SUSPENSION CONTROL ARMS AND BUSHINGS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing the control arm.
3. Develop a written procedure for visually inspecting the control arm and bushings.
4. Develop a written procedure for the removal and replacement of the control arm bushings.
5. Develop a written procedure for installing the control arm. Make sure the procedure includes all the necessary torque specifications.

JS1-L2-UXIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING LEAF SPRINGS

Equipment:

Hand tools
Hoist
Safety stands
Special tools as needed
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Place the vehicle securely on safety stands or lift it with a hoist. ___ ___ ___ ___

   (**CAUTION:** Be sure to use the proper equipment and observe all related safety rules when lifting the vehicle.)

3. Visually inspect the leaf spring. Record the results on the check list below. Refer to item 4 of AS1-L2-UXIII. ___ ___ ___ ___

Spring leaves	OK____	NOT OK____
Tie bolt	OK____	NOT OK____
Interleaves	OK____	NOT OK____
Rebound clips	OK____	NOT OK_____
Shackles/bushings	OK____	NOT OK_____

   If any of the above items were marked "NOT OK," describe the problem and recommend repair procedures.

4. Complete AS1-L2-UXIII. Following the procedure developed in item 2 of AS1-L2-UXIII, remove the leaf spring. ___ ___ ___ ___

   (**CAUTION:** Leaf springs are very heavy. Have an assistant help to hold and lower the spring assembly from the vehicle. Serious personal injury could result from being struck by a falling spring.)

5. Following the procedure developed in item 4 of AS1-L2-UXIII, inspect the spring components. In the space below, record any problems found in the spring components and suggest procedures for repair. _ _ _ _

6. Following the procedure developed in item 3 of AS1-L2-UXIII, replace the spring eye bushing. _ _ _ _

7. Following the procedure developed in item 5 of AS1-L2-UXIII, install the leaf spring. Once installation is complete, lower the vehicle. _ _ _ _

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency T2. Final evaluation for T2 will be made at the end of JS1-L2-UXIV.)

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING REAR COIL SPRINGS AND INSULATORS

Equipment:

Hand tools
Hoist
Safety stands
Special tools as needed
Safety glasses

Procedure: Evaluation: 3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Place the vehicle securely on safety stands or lift it with a hoist. ___ ___ ___ ___

   (**CAUTION:** Be sure to use the proper equipment and observe all related safety rules when lifting the vehicle.)

3. Visually inspect the coil spring. Record any problems found during the inspection (such as broken or collapsed coils or evidence of coil clash) in the space below. ___ ___ ___ ___

4. Complete AS2-L2-UXIII. Following the procedure developed in item 2 of AS2-L2-UXIII, remove the rear coil spring from the vehicle. ___ ___ ___ ___

   (**CAUTION:** Be sure to follow manufacturer's instructions carefully during removal and installation of the rear coil spring. Failure to do so could result in serious personal injury.)

5. Inspect the rear coil spring components. Use the checklist below to note any damage. ___ ___ ___ ___

Control arms	OK____	NOT OK____
Disconnected control arm bushings and bolts (if applicable)	OK____	NOT OK____
Shock absorber	OK____	NOT OK____
Disconnected stabilizer bushings	OK____	NOT OK____

If any of the above items were marked "NOT OK," describe the problem and recommend repair procedures.

6. Following the procedure developed in item 3 of AS2-L2-UXIII, install the coil spring. ____

   a. Clean spring mounting pads before installation.

   b. Be sure to reinstall any rubber insulators before installing the spring.

   c. Tighten all fasteners to specified torque.

   d. Lower the vehicle.

   Average of the above evaluations* ____

   (*This average is a partial evaluation for Competency T1. Final evaluation for T1 will be made at the end of JS5-L2-UXIV.)

JS3-L2-UXIII

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING REAR SUSPENSION CONTROL ARMS AND BUSHINGS

Equipment:

Hand tools
Hoist
Special tools
Safety glasses

Procedure:

		Evaluation 3 2 1 N
1.	Wear safety glasses while doing all procedures on this job sheet.	___ ___ ___ ___
2.	Place the vehicle securely on safety stands or lift it with a hoist. (**CAUTION:** Be sure to use the proper equipment and observe all related safety rules when lifting the vehicle.)	___ ___ ___ ___
3.	Complete AS3-L2-UXIII. Following the procedure developed in item 2 of AS3-L2-UXIII, remove the rear suspension control arm.	___ ___ ___ ___
4.	Following the procedure developed in item 3 of AS3-L2-UXIII, inspect the control arm and bushings. Record any problems with the control arm bushings in the space below.	___ ___ ___ ___
5.	Following the procedure developed in item 4 of AS3-L2-UXIII, replace the control arm bushings.	___ ___ ___ ___
6.	Following the procedure developed in item 5 of AS3-L2-UXIII, install the control arm on the vehicle. Lower the vehicle when installation is complete.	___ ___ ___ ___
	Average of above evaluations*	___ ___ ___ ___

(*This average is the final evaluation for Competency T4.)

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING REAR SUSPENSION SHOCK ABSORBERS

Equipment:

Hoist
Hand tools
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. — — — —

2. Place the vehicle securely on safety stands or lift it with a hoist. Support the vehicle under the rear axle. — — — —

   (NOTE: It is important to support the axle during shock removal to prevent the axle from dropping down and damaging the brake line or causing injury.)

   (**CAUTION:** **Be sure to use the proper equipment and observe all related safety rules when lifting the vehicle.**)

3. Carefully inspect the shock absorbers for the following. — — — —

   Secureness of mounting OK____ NOT OK____
   Condition of rubber bushings OK____ NOT OK____
   Excessive fluid leakage OK____ NOT OK____
   Condition of piston rod and tube OK____ NOT OK____

   If any of the above items were marked "NOT OK," describe the problem and recommend repair procedures.

4. Following the procedure outlined below, remove the shock absorber. — — — —

   (NOTE: Do not grasp the piston rod with a wrench or pliers. Use the flats provided at the end of the piston rod.)

   a. Secure the piston rod to keep it from turning. Remove the upper shock absorber retaining nut, washer, and rubber bushing.

b. Remove the bolts or nut holding the lower end of the shock absorber to the axle and remove the shock absorber.

5. Inspect the shock absorber by fully extending and compressing the piston rod several times. Complete the checklist below. ____

(NOTE: Extreme force is required to compress a gas-charged shock; therefore, this inspection procedure may be difficult to perform on a gas-charged shock.)

Is action rough? YES____ NO____

Does the shock make any unusual noise? YES____ NO____

Does the shock exhibit resistance to movement in both directions? YES____ NO____

Does the shock expand when released from a compressed position (gas-charged only) YES____ NO____

If any of the above items were marked "YES," describe the problem and recommend repair procedures.

6. Hold the removed shock in an upright position and extend it fully. Then turn it over and compress it fully. Repeat this action three times to expel any air trapped in the hydraulic cylinder. ____

7. Repeat step 6 and record the results below. ____

8. Following the procedure outlined below, install the shock absorber. ____

a. In the space below, determine and record any torque specifications related to installing the shock absorber.

(HINT: Use an appropriate service manual.)

b. Hold the removed shock in an upright position and extend it fully. Then turn it over and compress it fully. Repeat this action at least three times to expel any air trapped in the hydraulic cylinder.

c. Fully extend the shock absorber and install the lower mounting washer and grommet (if used) on the piston rod.

d. Insert the shock through the upper mounting hole.

e. Install the upper mounting grommet and washer; then install and tighten the retaining nut to the specified torque.

f. Install and tighten the bolts or nut retaining the lower end of the shock to the specified torque.

g. Lower the vehicle.

Average of above evaluations* ____

(*This average is a partial evaluation for Competency T2. Final evaluation for T2 will be made at the end of JS1-L2-UXIV.)

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIII: THE DESIGN AND OPERATING PRINCIPLES OF THE REAR SUSPENSION SYSTEM

UNIT XIII TEST

PART I. DIAGNOSING AND REPAIRING REAR SUSPENSION SYSTEMS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. All rear suspension systems must provide a smooth and stable ride.

____ 2. Leaf springs may be either single or multiple leaf.

____ 3. A leaf spring shackle is used to connect one end of the spring to the frame.

____ 4. Coil spring rear suspensions are less complex than leaf spring rear suspensions.

____ 5. Like coil spring front suspensions, coil spring rear suspensions use control arms and ball joints.

____ 6. Some coil spring rear suspensions use a track bar to reduce differential twist during acceleration and deceleration.

____ 7. A trailing arm rear suspension is commonly used on small rear-wheel-drive vehicles.

____ 8. A semi-independent rear suspension consists of two trailing arms, which are connected by a lateral beam.

____ 9. The independent trailing arm rear suspension is generally found on high-performance automobiles with rear-wheel drive.

____ 10. A MacPherson strut rear suspension rarely uses strut rods to control forward/backward movement of the suspension.

____ 11. MacPherson strut rear suspension systems are classified as coil spring rear suspensions.

____ 12. On rear-wheel-drive coil spring rear suspensions, the control arms are mounted to the differential and frame via rubber bushings.

____ 13. Springs are not used on MacPherson strut rear suspensions.

____ 14. Leaf spring rear suspensions use control arms.

____ 15. On rear suspensions, stabilizer bars control both lateral and side sway movement of the vehicle.

____ 16. MacPherson strut rear suspensions call for a reinforced body.

____ 17. During rear coil spring removal, the brake line should be removed at the axle housing.

____ 18. Before the rear coil springs are removed, the lower end of the shock absorbers must be removed.

____ 19. During rear coil spring removal, the vehicle frame is supported and the axle housing rests on some sort of jack.

____ 20. Coil springs are usually mounted behind the rear axle on coil spring rear suspension systems.

____ 21. Torsion bar springs are used on some rear suspension systems.

____ 22. Shiny wear marks on the spring coils are evidence of spring clash.

____ 23. Spring clash can be caused by weak springs.

____ 24. Vehicle ride height measurement can give a good indication of the condition of the rear springs.

____ 25. The control arms must be removed from the differential housing before the coil springs can be removed.

____ 26. During removal, coil springs may fall out as the axle is lowered.

(NOTE: The student must obtain a minimum score of ____ on Part I of the Unit XIII Test in order to receive an evaluation for Competency T1.)

PART II. INSPECTING AND REPLACING SHOCK AND SPRING ASSEMBLIES

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 27. During leaf spring inspection, all the leaves should be checked.

____ 28. During leaf spring inspection, shackles or bushings should be checked.

____ 29. The shocks usually have to be removed from the axle during leaf spring removal.

____ 30. Leaf spring bushings can be replaced while the leaf spring is attached to the vehicle.

____ 31. Worn suspension parts should be replaced with new parts instead of used ones.

____ 32. Leaf spring bushings can be more easily inspected before the springs are removed from the vehicle.

____ 33. During a leaf spring inspection, the technician should check the tie bolt.

____ 34. Either a special press or a shop press with special adapters should be used to replace spring eye bushings.

____ 35. Some rear shock top mountings must be removed through the trunk.

____ 36. Rear shocks should not be purged of air.

____ 37. Gas-charged shocks will rapidly expand when removed.

____ 38. During rear shock removal, the lower mount is usually removed first.

(NOTE: The student must obtain a minimum score of ____ on Part II of the Unit XIII Test in order to receive an evaluation for Competency T2.)

PART III. SERVICING REAR SUSPENSION COMPONENTS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 39. Rear suspension rubber bushings are normally repaired after the control arms are removed.

____ 40. The rear axle should be supported during rear control arm removal and replacement.

____ 41. Control arms can be easily damaged during removal of rear suspension bushings.

____ 42. Rear control arms are not replaced on leaf spring suspensions.

____ 43. Rear control arm bushings are best removed with a torch.

____ 44. The track bar should be checked during an inspection of rear suspension components.

____ 45. When repairing rear suspensions, the technician should remove control arms one at a time.

(NOTE: The student must obtain a minimum score of ____ on Part III of the Unit XIII Test in order to receive an evaluation for Competency T4.)

ANSWERS TO UNIT XIII TEST

1. t
2. t
3. t
4. f
5. f
6. f
7. f
8. t
9. f
10. f
11. f
12. t
13. f
14. f
15. f
16. t
17. t
18. t
19. t
20. f
21. t
22. t
23. t
24. t
25. f
26. t
27. t
28. t
29. t
30. f
31. t
32. t
33. t
34. t
35. t
36. f
37. t
38. f
39. t
40. t
41. t
42. t
43. f
44. t
45. t

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIV: AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROLS

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and replace air shocks and electronic suspension control components. The student will demonstrate mastery of the material by achieving a score of ______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify the characteristics of the design of the air adjustable shock absorber (Competency T1, Part I of the Unit XIV Test).

II. Identify the characteristics and operating principles of electronic level control systems (Competency T1, Part I of the Unit XIV Test).

III. Identify the characteristics and operating principles of electronic air suspension systems (Competency T1, Part I of the Unit XIV Test).

Lesson 2. I. Identify the procedures for inspecting air adjustable shock absorbers (Competency T2, Part II of the Unit XIV Test).

II. Identify the procedures for replacing air adjustable shock absorbers (Competency T2, Part II of the Unit XIV Test).

III. Identify the procedures for repairing air lines (Competency T2, Part II of the Unit XIV Test).

IV. Identify the procedures for diagnosing electronic level control components (Competency T1, Part I of the Unit XIV Test).

V. Identify the procedures for repairing and replacing electronic level control components (Competency T1, Part I of the Unit XIV Test).

VI. Demonstrate the ability to:

a. Inspect and replace air adjustable shock absorbers (Competency T2, JS1-L2-UXIV).

b. Test electronic level control performance (Competency T1, JS2-L2-UXIV).

c. Leak test an electronic level control system (Competency T1, JS3-L2-UXIV).

d. Remove and install an electronic level control compressor assembly (Competency T1, JS4-L2-UXIV).

e. Test an electronic level control height sensor (Competency T1, JS5-L2-UXIV).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D050 and D052.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIV: AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROLS

CONTENTS OF THE UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: DESIGN AND OPERATION OF AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROL SYSTEMS

    a. Information outline

    b. Assignment sheet

    AS1-L1-UXIV: Air Shock and Electronic Suspension Control

2. Lesson 2: DIAGNOSING AND REPLACING AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROL SYSTEMS

    a. Information outline

    b. Assignment sheets

    AS1-L2-UXIV: Procedures for Removing and Installing an Electronic Level Control Compressor
    AS2-L2-UXIV: Procedures for Testing an Electronic Level Control Height Sensor

    c. Job sheets

    JS1-L2-UXIV: Inspecting and Replacing Air Adjustable Shock Absorbers
    JS2-L2-UXIV: Testing Electronic Level Control Performance
    JS3-L2-UXIV: Leak Testing the Electronic Level Control System
    JS4-L2-UXIV: Removing and Installing an Electronic Level Control Compressor
    JS5-L2-UXIV: Testing an Electronic Level Control Height Sensor

E. Unit test

F. Answers to unit test

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UXIV before taking the Unit XIV Test. Students should do AS1-L2-UXIV in conjunction with JS4-L2-UXIV and AS2-L2-UXIV in conjunction with JS5-L2-UXIV.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIV: AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROLS

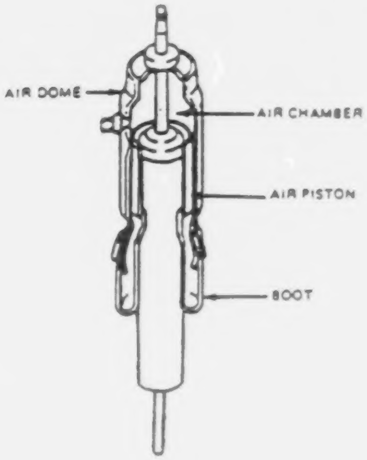
LESSON 1: DESIGN AND OPERATION OF AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROL SYSTEMS

I. Design of the air adjustable shock absorber

A. Air adjustable shock absorbers are basically conventional rear shock absorbers that are enclosed in air chambers. Some vehicles come equipped with air adjustable shocks; air adjustable shocks can also be added to a vehicle after manufacture.

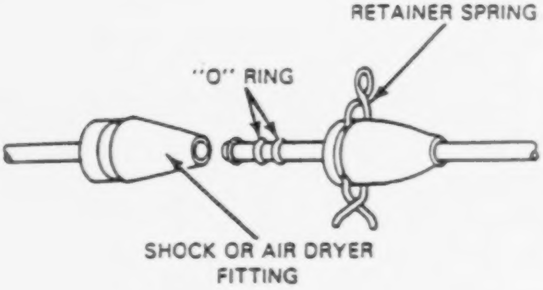
B. A pliable nylon-reinforced neoprene rubber boot is used to seal the shock absorber dust tube to the shock absorber reservoir tube. When the driver wishes to adjust vehicle ride height (to allow for a heavy load, for example), he or she activates an electrical switch which increases or reduces air pressure in the shock absorber air chamber. The increase or reduction in air pressure forces the shock to extend or retract, thus raising or lowering the vehicle ride height.

(**CAUTION**: Always connect air shocks in parallel with a common air valve. This prevents the failure of only one shock and reduces the risk of a serious accident.)



C. Plastic lines connect the two shock absorbers to an air valve mounted at the rear of the vehicle.

1. Brass fittings or rubber o-rings and snap lock connectors are used to connect the plastic line to the shocks and the control valve. The control valve is a Schraeder valve, similar to those used as tire valve stems.



2. A minimum air pressure of about 15 psi should be maintained at all times to reduce rubber boot friction and assure long shock life. Minimum air pressure varies, depending on the shock manufacturer.

3. Normally air pressure applied to the air shocks should not exceed 90 psi. Pressure limits vary, depending on the shock manufacturer.

4. Pressure is measured with a normal tire pressure gauge capable of registering the maximum pressure that the shocks can withstand.

D. If the system develops a leak and loses air pressure, the shock absorber will continue to function as a conventional shock absorber.

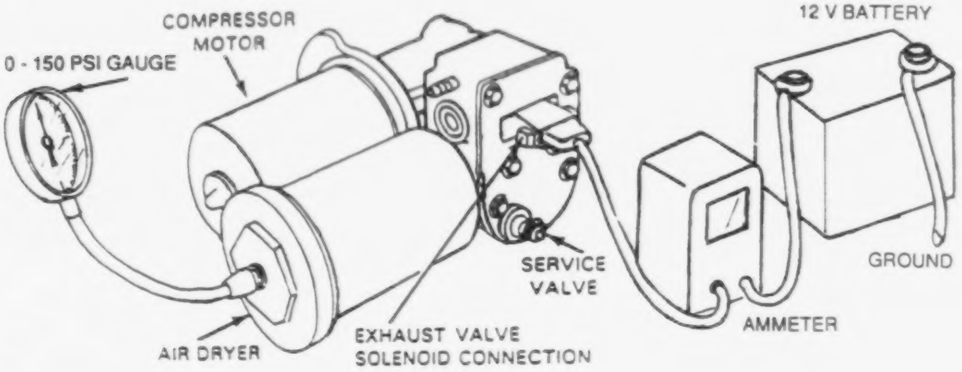
II. Electronic level control systems

A. Electronic level control systems automatically adjust vehicle ride height according to vehicle weight by increasing or reducing pressure in the air chambers of the adjustable air shocks.

B. Components of the electronic level control system

1. Electronic level control systems include air adjustable shock absorbers, air lines, air compressor, and sensor valve.

2. Electronic level control systems usually use a positive displacement, single-piston air compressor driven by a permanent magnet 12-volt direct current motor. The compressor is normally mounted in the engine compartment of the vehicle. When the ignition is turned on and weight is added to the vehicle, the compressor will run, supplying compressed air to the shocks. An exhaust solenoid is attached to the compressor and receives current from the battery's positive terminal. If weight is removed from the vehicle, the solenoid is activated and allows the system to exhaust air in order to readjust vehicle height.



3. Electronic level control systems use an air dryer, consisting of a dry chemical (desiccant) that absorbs moisture from the atmosphere before it is delivered to the air shocks. The air dryer also returns the moisture to the atmosphere when the air is exhausted. The dryer contains a valving arrangement that maintains a minimum air pressure in the air shocks at all times.

4. As mentioned above, electronic level control systems include an exhaust solenoid. When activated by the height sensor, the solenoid exhausts air from the system. The exhaust solenoid also holds compressor pressure output to a predetermined limit.

5. A pressure-limiting valve controls the maximum line pressure to achieve the smoothest ride. The limiting valve is not included on all electronic level control systems.

6. When activated by the height sensor, the relay completes the electrical circuit to the compressor motor.

7. Most electronic level control systems use an electric height sensor, which is mounted on a frame crossmember. The height sensor is connected to the rear axle by a moveable arm. When vehicle height changes, the height sensor activates the relay, which turns the compressor on and off. (As indicated above, the action of the compressor provides pressure to the shock air chamber, thus extending the shock and raising the vehicle.) The height sensor also controls the operation of the exhaust solenoid.

   (NOTE: In order to prevent the unnecessary activation of the compressor during normal ride motion, the sensor has a built-in delay of 10 to 28 seconds. In order to protect the compressor during a major air leak, the sensor automatically limits the compressor to a maximum running time of five minutes.)

III. Electronic air suspension systems

A. Electronic air suspension systems are currently used only on a few luxury automobiles. Listed below are features and components that electronic air suspension systems and electronic level control systems have in common.

1. Both systems use a single-cylinder 12-volt compressor.

2. Both systems use a dryer to remove moisture from system air.

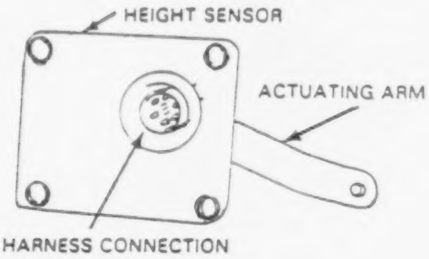
3. Both systems use height sensors to determine vehicle ride height.

B. Though in many ways similar to the electronic level control system, the electronic air system is far more sophisticated. Listed below are various technologically advanced features of the electronic air suspension.

1. At both the front and rear wheels, electronic air suspensions use air springs made of rubber and plastic instead of conventional coil springs. The rubber and plastic air springs are mounted much like conventional coil springs.

2. Electronic air suspensions are equipped with front and rear shocks/struts that are similar to those used in conventional suspensions.

3. In electronic air suspensions, height sensors mounted at each front wheel and at the rear axle relay electronic signals to a control module (a computer). The control module maintains proper vehicle ride height based on these signals.



C. Operation of the electronic air suspension system

1. When weight is added to a vehicle, the vehicle body will settle. As settling occurs, the height sensors are moved and, as a result, send signals to the control module (a computer). The control module then activates the air compressor (through a relay) and opens solenoid valves on the air springs. This causes the suspension to rise and the height sensors to move. When the predetermined height is reached, the control module closes the solenoid valves and turns off the compressor.

2. When weight is removed from the vehicle, the body will rise. As the body rises, the height sensors are moved. Upon moving, the sensors send signals to the control module. The control module opens the compressor vent solenoid and the air spring solenoid valves. When the predetermined height is reached, the module closes the compressor vent solenoid and the air spring solenoid valves.

MODULE: STEERING AND SUSPENSION SYSTEMS

AIR SHOCK AND ELECTRONIC SUSPENSION CONTROL

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. List six major components of an electronic level control system.

2. The air dryer in an electronic level control system removes moisture from the air being delivered to what suspension component?

3. What kind of springs are used in an electronic air suspension system?

MODULE: STEERING AND SUSPENSION SYSTEMS

AIR SHOCK AND ELECTRONIC SUSPENSION CONTROL

(ANSWER SHEET)

1. Compressor relay, compressor air shocks, pressure limit valve, exhaust solenoid, height sensor, air line, air dryer
2. Shock absorbers
3. Air springs

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIV: AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROLS

LESSON 2: DIAGNOSING AND REPLACING AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROL SYSTEMS

I. Inspecting an air adjustable shock absorber

  A. Procedure for visually inspecting an air adjustable shock absorber

  (NOTE: Visually inspect the air adjustable shock absorber in the same way as a conventional shock absorber. In addition, perform the inspection procedures listed below.)

    1. Visually inspect the condition of the air lines.

      a. Inspect air lines for breaks or kinks.

      b. Inspect lines for proper routing. Plastic lines will melt if they are too close to exhaust components .

      c. Inspect the condition of air line fittings.

    2. Inflate the shocks to the maximum pressure recommended by the manufacturer and inspect the condition of the rubber air boots.

    (NOTE: Light cracking of the rubber boot does not necessarily indicate a bad boot. If boots are cut, leaking, or badly deteriorated, the shock absorber must be replaced.)

  B. Procedure for inspecting air adjustable shock absorbers for air leaks

  (NOTE: Though a system may exhibit evidence of air leaks, the source is sometimes difficult to locate.)

    1. Apply a soapy water solution to the various components.

    2. Inflate the system to the maximum pressure recommended by the manufacturer.

    3. Raise and support the vehicle.

    (**CAUTION:** Follow all related safety procedures when lifting a vehicle.)

    4. Apply soapy water to the shock, lines, fittings, and air valve.

    5. Note if the soapy water begins to bubble. Bubbling is an indication of leaks.

II. Replacing the air adjustable shock absorber

  A. Procedure for removing an air adjustable shock absorber

    1. Discharge all air from the system by depressing the control valve.

2. Raise the vehicle and support it under the rear axle.

(**CAUTION**: Failure to support the vehicle weight by the axle housing can result in serious injury when the shock is removed and the axle housing drops 4" to 7".)

3. Disconnect the air lines from the air adjustable shock absorbers.

4. Disconnect the upper shock mounting.

5. Disconnect the lower shock mounting and remove the shock.

B. Procedure for installing an air adjustable shock absorber

1. Install washers and rubber grommets on the shock. (Some shocks may not use washers or grommets.)

2. Attach the lower shock mounting and tighten it to the specified torque.

3. Attach the upper shock mounting and tighten it to the specified torque.

4. Connect the air lines. Tighten the fittings to the specified torque if applicable.

5. Inflate the shocks to the maximum pressure.

6. Using a soapy water solution, check all air line connections for leaks.

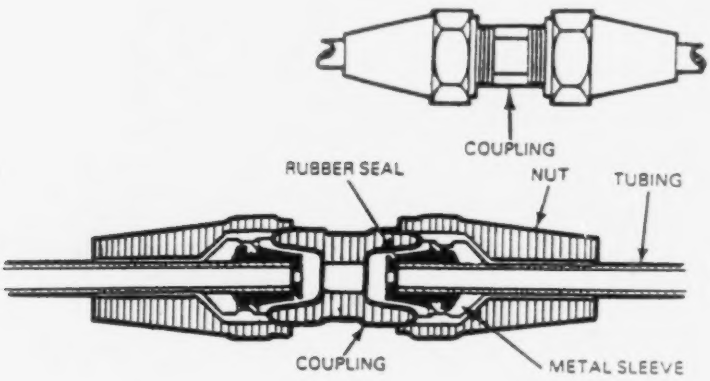
7. Adjust to desired pressure and ride height.

III. Procedures for repairing air lines

(NOTE: The plastic air lines are often mispositioned, causing them to tear, break, or fall against hot exhaust pipes. Repair kits can be very useful in restoring damaged lines.)

A. Detach the line and cut off the damaged portion with a razor blade or sharp knife.

B. Splice the existing tubing to the replacement tubing with a special coupling such as the one shown below.



C. Reinstall the air line.

1. Tie the tubing to the vehicle with tie straps. Route the lines in a manner that will prevent damage.
2. Activate the compressor and leak test the repaired area, using soapy water as described above.

IV. Diagnosing electronic level control components

(NOTE: The following procedures cover only the major components of electronic level control systems. The procedures are very general in nature. Refer to the proper service manual for complete and detailed information for the vehicle to be serviced.)

A. Procedure for testing the height sensor

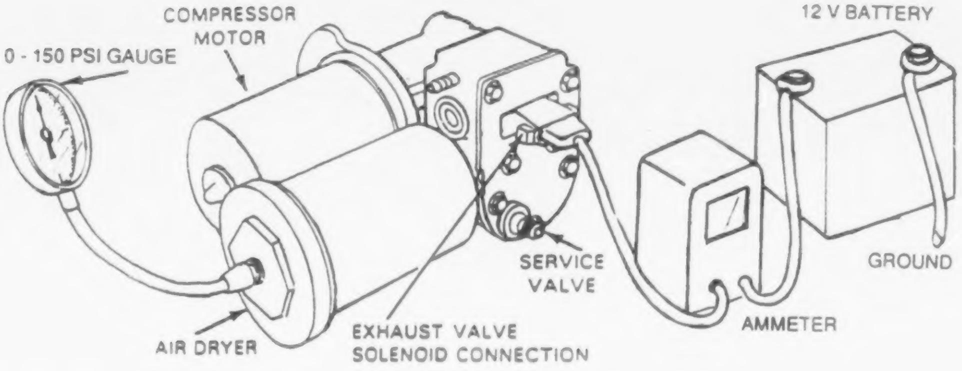
1. Depending on the vehicle being serviced, either cycle the ignition on and off or turn the ignition on and shift the gear selector from park to reverse and back to park.
2. Raise and secure the vehicle. Support the rear axle at normal ride height.
3. Inspect wiring connections at the height sensor and the sensor ground.
4. Disconnect the link from the height sensor arm.
    a. Move the height sensor arm up. After a delay of 10 to 28 seconds (time varies depending on model of vehicle), the air compressor should come on, thus filling the shock absorber air boots.
    b. Once the boots start to fill, move the arm down. The compressor should stop running.
    c. After a delay of 10 to 28 seconds, the shocks should start to deflate.

B. Procedure for testing compressor performance

(NOTE: The compressor may be tested either while on the car or on a work bench.)

1. Disconnect the wiring from the compressor motor and the exhaust solenoid terminals.
2. Disconnect the pressure line from the dryer and attach a 0- to 150-psi pressure gauge to the dryer fitting.

3. Connect a 12-volt power supply to the compressor with an ammeter connected in series between the power supply and the compressor.



4. Current draw should not exceed 14 amps.

5. When the gauge reaches approximately 110 psi, shut off the compressor. Note whether the pressure holds or leaks down. (Allow the pressure to stabilize).

   (NOTE: If the compressor is permitted to run until it reaches 120 to 150 psi, the pressure relief valve in the exhaust solenoid will open and cause the system to leak down. This will result in a false leak indication.)

6. Compare the results of step "a" and step "b" above to the manufacturer's specifications and take appropriate action.

C. Adjusting the height sensor

1. The height sensor may be adjusted to raise ride height (compressor is activated by less suspension travel) or lower ride height (compressor is activated by more suspension travel).

2. Measure the vehicle's ride height. See Unit IX of this module for the procedure.

3. Procedure for raising ride height

   a. In order to change sensor adjustment, a slotted adjustment or an adjusting screw on the actuating arm assembly must be moved.

   b. On many units, ride height can be raised by loosening the lock nut that retains the metal arm to the plastic height sensor arm. The plastic actuator arm can then be slid upward, thus changing the actuator position. As the position of the actuator changes, the compressor is activated or deactivated. In this way, the air is added to shocks as needed to achieve the newly adjusted ride height.

4. Procedure for lowering ride height

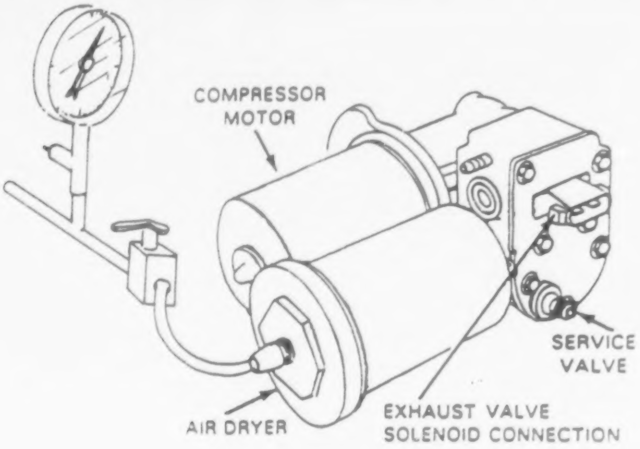
   a. Loosen lock nut and move the plastic arm downward to the bottom of the slot and retighten the lock nut.

b. If height cannot be properly adjusted, check vehicle ride height. Also check to see if the height sensor being used is the proper one for the vehicle.

D. Procedure for leak testing the system

(NOTE: The leak testing procedure outlined below requires the use of a pressure gauge with a "Schraeder" valve, a shut off valve, and adapters to connect the gauge and the valve into the system being tested.)

1. Tee a pressure gauge into the system between the dryer and the air line with a shut off valve positioned on the compressor side of the gauge.



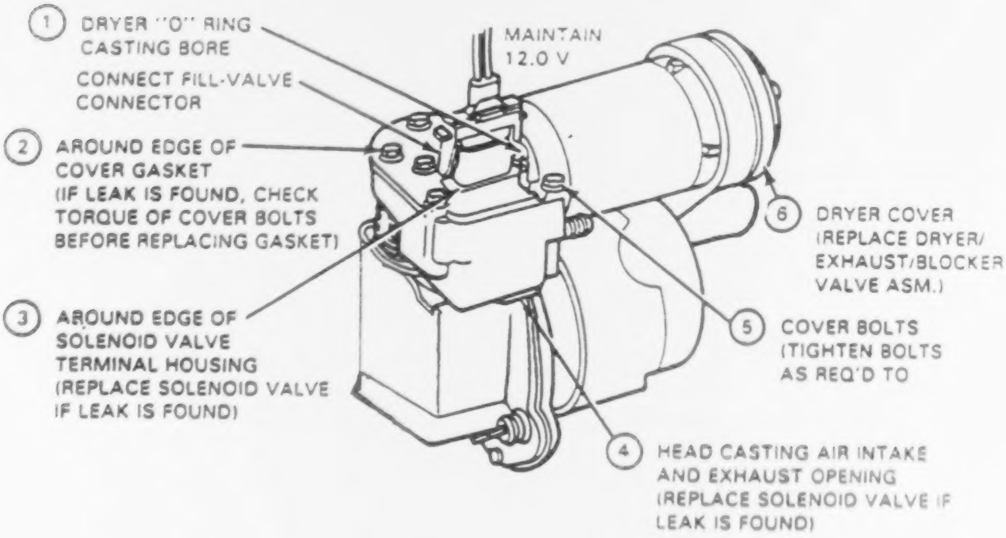
2. Open the shut off valve and apply shop air through the "Schraeder" valve until the gauge reads 100 to 120 psi.

3. If the gauge pressure starts to drop, a leak is indicated.

4. Isolate the compressor by closing the shut off valve.

5. If the gauge continues to drop when the shut off valve is closed, the leak is not in the compressor. Leak test all other components using a soapy water solution.

6. If gauge pressure stops dropping when the shut off valve is closed, the leak must be in the compressor. Apply a soapy water solution to the compressor and watch for air bubbles.



① DRYER "O" RING CASTING BORE
CONNECT FILL-VALVE CONNECTOR
MAINTAIN 12.0 V
② AROUND EDGE OF COVER GASKET (IF LEAK IS FOUND, CHECK TORQUE OF COVER BOLTS BEFORE REPLACING GASKET)
③ AROUND EDGE OF SOLENOID VALVE TERMINAL HOUSING (REPLACE SOLENOID VALVE IF LEAK IS FOUND)
④ HEAD CASTING AIR INTAKE AND EXHAUST OPENING (REPLACE SOLENOID VALVE IF LEAK IS FOUND)
⑤ COVER BOLTS (TIGHTEN BOLTS AS REQ'D TO
⑥ DRYER COVER (REPLACE DRYER/ EXHAUST/BLOCKER VALVE ASM.)

V. Repairing and replacing electronic level control components

A. Removing and reinstalling the compressor

1. Procedure for removing the compressor

a. Disconnect the electrical connectors from the exhaust solenoid and the motor terminals. Also connect the hose from the dryer.

b. Remove the screws retaining the compressor mounting bracket to the vehicle and remove the compressor.

c. Remove the mounting bracket fasteners and then remove the compressor from the mounting bracket.

2. Procedure for reinstalling the compressor

a. Install the compressor in reverse order of disassembly.

b. Tighten all fasteners to specified torque.

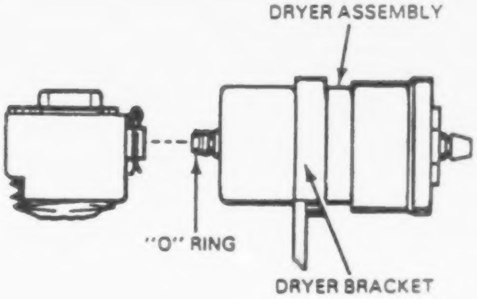
c. Lightly pressurize the system by adding air to the compressor service valve.

B. Disassembling, inspecting, and reassembling the compressor

(NOTE: Only a limited number of compressor parts can be serviced. The compressor should be disassembled only far enough to allow required service or replacement of parts.)

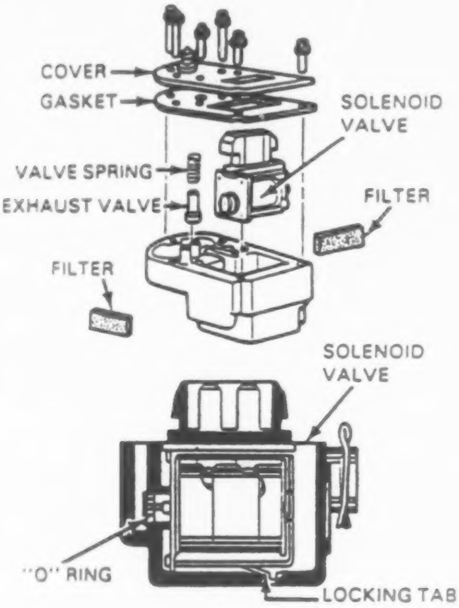
1. Procedure for disassembling the compressor

   a. Remove the dryer by rotating the retainer spring 90 degrees and pulling the dryer out of the casting. Remove the o-ring from the casting if it does not come out with the dryer.


DRYER ASSEMBLY
"O" RING
DRYER BRACKET

   b. Remove the screws attaching the cylinder head assembly to the compressor and remove the cylinder head assembly and o-ring.

   c. Remove cover screws from the head assembly. Remove the cylinder head cover and gasket, the exhaust valve and spring, and the solenoid valve and filters.


COVER
GASKET
SOLENOID VALVE
VALVE SPRING
EXHAUST VALVE
FILTER
FILTER
SOLENOID VALVE
"O" RING
LOCKING TAB

   d. Remove motor case screws and pull the case and magnet assembly off the armature.

   (NOTE: There are no serviceable parts in the compressor or motor; therefore, do not disassemble compressor or motor further. If parts within the compressor or motor are defective, the entire compressor or motor must be replaced.)

SSS 537

2. Procedure for visually inspecting the compressor

   a. Inspect compressor assembly for wear or damage. If wear and damage are found, the compressor and motor assembly must be replaced as a unit.

   b. Inspect motor for wear or damage. Like the compressor, the motor has no serviceable parts.

3. Procedure for reassembling a compressor

   a. Install all compressor parts in reverse order of disassembly.

   b. Make sure all defective compressor components are replaced.

   c. Tighten all fasteners to manufacturer's specified torque.

C. Removing and reinstalling the height sensor

1. Procedure for removing the sensor

   a. Raise and secure the vehicle.

   b. Disconnect the electrical connector from the height sensor.

   c. Disconnect the link from the height sensor arm.

   d. Remove the screws attaching the height sensor to the frame and remove the sensor.

   e. Install the sensor in reverse order of removal.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR REMOVING AND INSTALLING AN ELECTRONIC LEVEL CONTROL COMPRESSOR

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual and the information in this unit.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing and reinstalling the compressor assembly. Make sure the procedure includes all applicable torque specifications.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR TESTING AN ELECTRONIC LEVEL CONTROL HEIGHT SENSOR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual and the information sheets in this unit.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for testing the operation of the height sensor. Make sure the procedure includes the sensor delay time.

JS1-L2-UXIV

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND REPLACING AIR ADJUSTABLE SHOCK ABSORBERS

Equipment:

Hand tools
Hoist
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Following the procedure outlined below, remove the shock absorber. __ __ __ __

   a. Discharge all air from the system.

   b. Raise the vehicle and support the rear axle.

      (**CAUTION**: Failure to support the vehicle weight by the axle housing can result in serious injury when the shock is removed and the axle housing drops 4" to 7".)

   c. Disconnect the air line from the shock absorber.

   d. Remove the upper shock mounting.

   e. Remove the lower shock mounting and the shock absorber.

3. Inspect the condition of the plastic air lines and connectors. Any damaged or broken lines must be repaired or replaced. Describe below any repairs made to the air lines. __ __ __ __

4. Following the procedure outlined below, install the air adjustable shock absorber. __ __ __ __

   a. Determine and record below all torque specifications related to the installation of the shock absorber.

   b. Attach the lower shock mounting and tighten it to the specified torque.

   c. Attach the upper shock mounting and tighten it to the specified torque.

   d. Connect the air lines.

5. Inflate the shock absorbers to the maximum specified pressure. ___ ___ ___ ___

   a. Prepare a soapy water solution and apply it to all connections.

   b. Inspect for leaks at all connections and make repairs as necessary.

   c. Lower the vehicle.

6. Adjust shocks to desired height/pressure. ___ ___ ___ ___

Average of above evaluations* ___ ___ ___ ___

(*This average is a partial evaluation for Competency T2. Final evaluation for T2 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency T2 by averaging the evaluations of JS1-L2-UXIII, JS4-L2-UXIII, and JS1-L2-UXIV. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L2-UXIII	___	___	___	___
JS4-L2-UXIII	___	___	___	___
JS1-L2-UXIV	___	___	___	___
Final evaluation Competency T2	___	___	___	___

MODULE: STEERING AND SUSPENSION SYSTEMS

TESTING ELECTRONIC LEVEL CONTROL PERFORMANCE

Equipment:

Hand tools
Ammeter
Pressure gauge
Safety glasses

Procedure:

		Evaluation			
		3	2	1	N
1.	Wear safety glasses while doing all procedures on this job sheet.	___	___	___	___
2.	Disconnect the wiring harness at the compressor motor and the exhaust solenoid terminals.	___	___	___	___
3.	Disconnect the pressure line from the dryer and attach a 0- to 150-psi pressure gauge to the dryer fitting.	___	___	___	___
4.	Connect an ammeter in series between the positive battery terminal and the compressor.	___	___	___	___
5.	While monitoring the ammeter reading, run the compressor. When pressure reaches 110 psi, shut off the compressor and observe the pressure gauge. Use the below check list to record findings.	___	___	___	___

(NOTE: If the compressor is permitted to run until it reaches 120 to 150 psi, the pressure relief valve in the exhaust solenoid will open and cause the system to leak down. This will result in a false leak indication.)

Does the current draw exceed 14 amps? YES____ NO____

Does the compressor fail to reach 110 psi? YES____ NO____

Does pressure leak off? YES____ NO ____

If any of the above items were marked "YES," describe the problem and then refer to the appropriate service manual and recommend repair procedures. If all the above items were marked "NO," go to item 6 of this job sheet.

6. Reconnect the wiring and air line. — — — —

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency T1. Final evaluation for T1 will be made at the end of JS5-L2-UXIV.)

MODULE: STEERING AND SUSPENSION SYSTEMS

LEAK TESTING THE ELECTRONIC LEVEL CONTROL SYSTEM

Equipment:

Hand tools
0- to 150-psi pressure gauge
Shut off valve
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Tee the pressure gauge into the system between the dryer and the air line. Make sure the shut off valve is on the compressor side of the gauge. __ __ __ __

3. Open the shut off valve and apply shop air through the Schraeder valve until the gauge reads 100 to 120 psi. Note the pressure gauge. Does the pressure hold steady? __ __ __ __

   YES_____ NO_____

   If "YES" was marked, go to step 7 of this job sheet. If "NO" was marked, go to step 5 of this job sheet.

4. Isolate the compressor by closing the shut off valve. Does the pressure hold steady? __ __ __ __

   YES_____ NO_____

   If "YES" was marked, go to step 5 of this job sheet. If "NO" was marked, go to step 6 of this job sheet.

5. Apply a soapy water solution to all components except the compressor and observe for leaks. Record observations. __ __ __ __

6. Apply a soapy water solution to the compressor assembly and observe for leaks. Record observations. __ __ __ __

7. Based on the results of the tests and inspections performed in this job sheet, describe the condition of the system and recommend repair procedures, if necessary. _ _ _ _

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency T1. Final evaluation for T1 will be made at the end of JS5-L2-UXIV.)

JS4-L2-UXIV

MODULE: STEERING AND SUSPENSION SYSTEMS

REMOVING AND INSTALLING AN ELECTRONIC LEVEL CONTROL COMPRESSOR

Equipment:

Hand tools
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___
2. Complete AS1-L2-UXIV. Following the procedure developed in item 2 of AS1-L2-UXIV, remove the compressor assembly from the vehicle. ___ ___ ___ ___
3. Inspect the condition of the air line and wiring once they are disconnected from the vehicle. Record observations. ___ ___ ___ ___
4. Following the procedure developed in item 2 of AS1-L2-UXIV, install the compressor assembly. ___ ___ ___ ___
5. Test compressor performance. For this procedure, refer to JS2-L2-UXIV. Record the results of the performance test. ___ ___ ___ ___

6. Leak test the air line connection at the compressor with a soapy water solution. Record results below. __ __ __ __

NO LEAKS_____ LEAKS FOUND_____

If leaks are found, they must be repaired.

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competency T1. Final evaluation for T1 will be made at the end of JS5-L2-UXIV.)

MODULE: STEERING AND SUSPENSION SYSTEMS

TESTING AN ELECTRONIC LEVEL CONTROL HEIGHT SENSOR

Equipment:

Hand tools
Hoist
Safety glasses

Procedure:

		Evaluation 3 2 1 N
1.	Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2.	Place the vehicle securely on safety stands or lift it with a hoist. Support the axle so it is as close as possible to normal ride height.	__ __ __ __
3.	Complete AS2-L2-UXIV. Following the procedure developed in item 2 of AS2-L2-UXIV, test the operation of the height sensor. Use the below check list to record the test results. Lower the vehicle when the test is completed.	__ __ __ __

Do the shock absorbers fill when the control arm is moved upward? YES____ NO_____

Does the compressor stop running when the control arm is moved down? YES____ NO____

Do the shock absorbers deflate when the control arm is moved downward? YES____ NO_____

Is there a proper amount of delay before the shock absorber responds? YES____ NO____

If any of the above items were marked "NO," describe the problem and recommend appropriate repair procedures.

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competency T1. Final evaluation for T1 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency T1 by averaging the evaluations of JS1-L1-UXII, JS2-L1-UXII, JS3-L1-UXII, JS2-L2-UXIII, JS2-L2-UXIV, JS3-L2-UXIV, JS4-L2-XIV, and JS5-L2-UXIV. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L1-UXII	___	___	___	___
JS2-L1-UXII	___	___	___	___
JS3-L1-UXII	___	___	___	___
JS2-L2-UXIII	___	___	___	___
JS2-L2-UXIV	___	___	___	___
JS3-L2-UXIV	___	___	___	___
JS4-L2-UXIV	___	___	___	___
JS5-L2-UXIV	___	___	___	___
Final evaluation for Competency T1	___	___	___	___

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XIV: AIR ADJUSTABLE SHOCK ABSORBERS AND ELECTRONIC SUSPENSION CONTROLS

UNIT XIV TEST

PART I. DIAGNOSIS AND REPAIR OF ELECTRONIC SUSPENSIONS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. Electronic level control systems use air springs to control vehicle ride height.

____ 2. The air compressor used in electronic level control systems is driven by a belt that is attached to the engine.

____ 3. An exhaust solenoid links the compressor to the vehicle's exhaust system.

____ 4. A desiccant is a dry chemical that absorbs moisture.

____ 5. The height sensor is a mechanical device that energizes the compressor clutch.

____ 6. Electronic air suspension is used more commonly than electronic level control.

____ 7. Both electronic level control systems and electronic air suspension systems use height sensors.

____ 8. The suspension air compressor can be performance tested only when the vehicle is idling.

____ 9. To test the suspension air compressor performance, a gauge capable of reading 1,000 psi is necessary.

____ 10. Electronic level control is only used on rear suspensions.

____ 11. Suspension air compressors are normally mounted in the engine compartment.

____ 12. In air suspension systems, the air dryer contains a valve that maintains a minimum amount of air pressure in the system.

____ 13. In air suspension systems, the height sensor controls the operation of the compressor relay.

____ 14. In air suspension systems, height sensors have a built-in delay mechanism to prevent unnecessary actuation of the compressor.

____ 15. Electronic air suspensions are currently used only on a few types of luxury automobiles.

____ 16. Electronic air suspensions allow the driver to set vehicle ride height to his or her preference.

____ 17. A service manual is required to test most electronic level control devices.

____ 18. Most air suspension compressors can easily be rebuilt.

____ 19. The vehicle battery must be removed before the height sensor is tested.

____ 20. During a performance test of the air suspension compressor, the compressor should not leak down to under 175 psi.

(NOTE: The student must obtain a minimum score of ____ on Part I of the Unit XIV Test in order to receive an evaluation for Competency T1.)

PART II. DIAGNOSIS AND REPAIR OF AIR SHOCKS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 21. Air adjustable shock absorbers seldom use a single air inlet.

____ 22. Metal air lines connect air shocks to an air valve.

____ 23. If air shocks lose air pressure, they can still function as shocks.

____ 24. Air shocks are visually inspected in much the same way as conventional shock absorbers.

____ 25. Air shock absorbers should always be inflated and checked for leaks before they are installed.

____ 26. During a visual inspection of air shocks, the technician should check the air lines for routing.

____ 27. A good coating of petroleum jelly will prevent metal air lines from rusting.

____ 28. A change in pressure in air shocks will only affect vehicle ride height.

____ 29. An air shock must maintain a minimum pressure in order to reduce rubber boot friction.

____ 30. A Schraeder valve is used as the air shock control valve.

____ 31. The Schraeder valves are used in air shocks or similar to those used in tires.

SECTION B. **Select the best answer from the five choices listed.**

____ 32. If suspension air lines develop small leaks, the technician should

a. replace the shock absorbers.
b. solder the lines.
c. plug the line with synthetic rubber.
d. repair the leak with rubber cement.
e. repair the leak with an air line repair kit.

____ 33. When checking for air leaks, the technician should pressurize the system at

a. its maximum limit.
b. two-thirds of its maximum limit.
c. one-half of its maximum limit.
d. one-third of its maximum limit.
e. one-fourth of its maximum limit.

____ 34. Air lines can develop leaks as a result of

a. deterioration due to age.
b. being burnt by hot exhaust pipes.
c. kinks caused by poor routing.
d. cuts from road debris.
e. all of the above.

____ 35. The technician should remove the air from an air shock by

a. cutting an air line.
b. disconnecting an air line.
c. puncturing an air bladder.
d. depressing the control valve.
e. doing any of the above.

(NOTE: The student must obtain a minimum score of ____ on Part II of the Unit XIV Test in order to receive an evaluation for Competency T2.)

ANSWERS TO UNIT XIV TEST

1. f
2. f
3. f
4. t
5. f
6. f
7. t
8. f
9. f
10. t
11. t
12. f
13. f
14. f
15. t
16. f
17. t
18. f
19. f
20. f
21. f
22. t
23. t
24. t
25. f
26. t
27. f
28. f
29. t
30. t
31. t
32. e
33. a
34. e
35. d

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XV: WHEELS AND TIRES

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the various types of tires and wheels used on passenger cars, identify problems related to passenger car tires, and determine and make repairs. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the basic characteristics of the automobile tire (Competency U1, Part I of the Unit XV Test).

II. Identify the three basic types of passenger car tire construction (Competency U1, Part I of the Unit XV Test).

III. Identify the characteristics of tire cord body construction (Competency U1, Part I of the Unit XV Test).

IV. Identify the characteristics of tire grading systems (Competency U1, Part I of the Unit XV Test).

V. Identify the characteristics of tire load range (Competency U1, Part I of the Unit XV Test).

VI. Identify the characteristics of tire ply ratings (Competency U1, Part I of the Unit XV Test).

VII. Identify the characteristics of tire sizing (Competency U1, Part I of the Unit XV Test).

VIII. Identify the characteristics of convenience spare tires (Competency U1, Part I of the Unit XV Test).

IX. Identify the characteristics of wheel construction (Competency U1, Part I of the Unit XV Test).

Lesson 2.

I. Identify the procedures for inspecting tires (Competency U1, Part I of the Unit XV Test).

II. Identify the procedures for removing the tire and wheel assembly (Competency U4, Part II of the Unit XV Test).

III. Identify the procedures for installing the tire and wheel assembly (Competency U4, Part II of the Unit XV Test).

IV. Identify the procedures for rotating tires (Competency U4, Part II of the Unit XV Test).

V. Demonstrate the ability to:

- a. Inspect and inflate tires (Competency U1, JS1-L2-UXV).
- b. Rotate tires (Competency U4, JS2-L2-UXV).

Lesson 3. I. Identify the procedures for dismounting tires (Competency U4, Part II of the Unit XV Test).

II. Identify the procedures for mounting tires (Competency U4, Part II of the Unit XV Test).

III. Identify the procedures for repairing tubeless tires with the patch plug and the patch methods (Competency U4, Part II of the Unit XV Test).

IV. Demonstrate the ability to:

- a. Dismount and mount tires (Competency U4, JS1-L3-UXV).
- b. Repair punctures in tubeless tires (Competency U4, JS2-L3-UXV).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D065, D066, D068, D072, and D073.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XV: WHEELS AND TIRES

CONTENTS OF THE UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: TIRE AND WHEEL DESIGN

    a. Information outline

2. Lesson 2: TIRE INSPECTION AND ROTATION

    a. Information outline

    b. Assignment sheet

    AS1-L2-UXV: Procedure for Rotating Tires

    c. Job sheets

    JS1-L2-UXV: Inspecting and Inflating Tires
    JS2-L2-UXV: Rotating Tires

2. Lesson 3: TIRE MOUNTING AND PUNCTURE REPAIR

    a. Information outline

    b. Job sheets

    JS1-L3-UXV: Dismounting and Mounting Tires
    JS2-L3-UXV: Repairing Punctures in Tubeless Tires

E. Unit test

F. Answers to unit test

REFERENCES

Buick Division, General Motors Corporation. 1982 Buick Chassis Service Manual. Buick Division, General Motors Corporation. 1981.

Chrysler Corporation. Service Manual, Rear Wheel Drive 1985 Passenger Cars. Chrysler Corporation. 1984.

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Moog Automotive Inc. Moog Front End Service Manual, Inspection and Service Procedures. St. Louis, Missouri: Moog Automotive Inc. 1986.

Toboldt, William K. and Johnson, Larry. Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair. South Holland, Illinois: The Goodheart-Willcox Company, Inc. 1981.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L2-UXV in conjunction with JS2-L2-UXV.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XV: WHEELS AND TIRES

LESSON 1: TIRE AND WHEEL DESIGN

I. Automotive tires provide traction and absorb road shocks. Typical automotive tires must perform well on a variety of road surfaces and driving conditions. Tires must provide traction on asphalt, concrete, gravel, and dirt. Tires must also be designed to function as effectively on wet or snow-covered roads as on dry roads. Most of the tires used today are tubeless; however, some tube tires are still produced.

A. In a tubeless tire, air under pressure is retained by the tire and wheel. A soft rubber inner liner is built into the tire to prevent air from leaking through the tire fabric (plies).

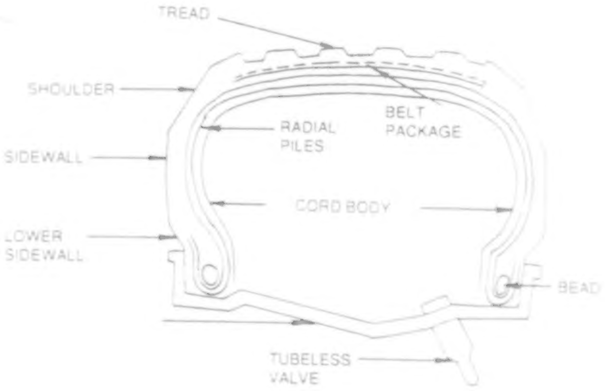
B. In tires using tubes, both the tire and an inner tube are mounted on a wheel. The tube is inflated and retains the air inside the tire. Tires with tubes are seldom used in today's cars and light trucks.

II. There are three basic types of passenger car tire construction: bias-ply, bias-belted, and radial-ply. All tire types have the following components: beads, cord body, and tread.

A. Beads are bands of strong steel wire, which are fastened to the tire plies and molded to the inner circumference of the tire. The beads hold the tire in position on the rim.

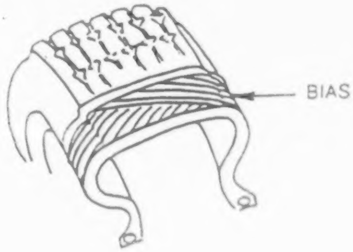
B. The cord body consists of layers of rubber-impregnated fabric (plies). These layers are molded together in rubber to form the tire. The cord body is attached to the steel bead wires. The way the plies are assembled determines the tire construction design (radial plies, bias-belted, etc.). The number of plies determines the load-carrying capacity of the tire.

C. The tread is the part of the tire that contacts the road. The tread rubber is molded directly to the cord body. Rubber is also molded to the cord body sidewalls. Varying tread designs and rubber compounds are used to comply to specific tire designs.

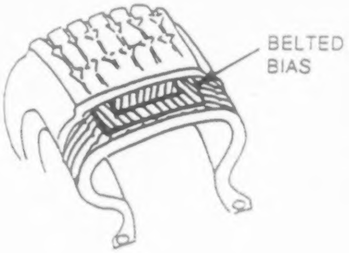


III. Tire cord body construction

A. Bias-ply tires consist of two or possibly even four or more plies placed one on top of another. The cords run in a crisscross (bias) pattern from bead to bead. Plies are constructed of rayon, nylon, polyester, etc.

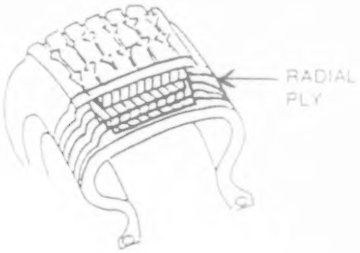


B. Bias-belted tires are constructed like bias-ply tires. However, bias-belted tires have two or more layers of tread-reinforcing plies or belts wrapped around the circumference of the tire under the tread. These "belts" do not extend to the sidewalls but rather are positioned under the tread area only. The belts are usually constructed of fiberglass, rayon, or steel. The added belts allow for better wear and handling and increased puncture resistance.



C. In radial-ply tires, the plies of the cord body run in straight lines, parallel to each other and perpendicular to the beads. The plies are at right angles to the tire tread. Two or more belts, made of either fabric or steel, are laid on top of the cord body, under the tread section. Radial-ply tires offer better traction, increased tread life, softer ride and less rolling resistance, which allows for better fuel economy. Radial-ply tires are, therefore, used on the majority of today's passenger cars.

(NOTE: Vehicles should not be operated with both radial- and bias-ply tires due to the different handling characteristics of the two tires.)



IV. Tire grading (uniform tire-quality grading system)

A. The National Highway Safety Administration established standards of quality for passenger tires. These standards fall into the categories of tread wear, traction, speed, and ability to dissipate heat. The tire's rating in these various categories is molded into the tire during its construction.

B. In the category of tread wear (length of tread life), each tire is assigned a grade number: 90, 100, etc. A tire with a grade of 180, for example, should wear twice as long as one with a grade of 90.

C. The letters A, B, and C are used to rate a tire's ability to provide traction during wet road conditions. A tire with an A rating offers the best traction under wet conditions while C offers minimum traction under wet conditions.

D. The letters A, B, and C are also used to indicate the tire's ability to dissipate or resist heat. A tire with a rating of A has the greatest ability to dissipate or resist heat while a tire rated C has the least ability to resist heat.

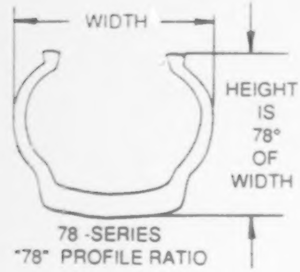
E. A tire's speed rating indicates the maximum speed at which a tire can safely operate. The letter S, H, or V is added to the tire size after the aspect ratio designation. A speed rating of "S" indicates a maximum safe operating speed of up to 112 MPH; H indicates a maximum safe operating speed of up to 130 MPH; V indicates a maximum safe operating speed of over 130 mph.

V. Load range is a term used to identify the size of a given tire, its inflation limit, and its maximum load. Again the letters A, B, and C are used. The letter C indicates a greater load-carrying capacity than the letter A.

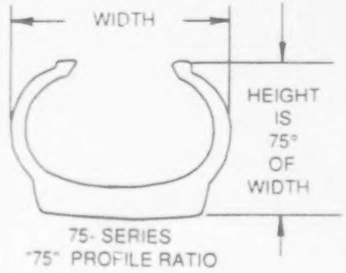
VI. A tire's ply ratings are a general indication of its load-carrying capacity. The ply rating is molded into the tire's sidewall. The ply rating number is not necessarily the same as the number of actual plies. For example, a tire with a two-ply sidewall construction may receive a four-ply rating. The two-ply tire would receive this rating if it had a four-ply load-carrying capacity.

VII. Tire sizing

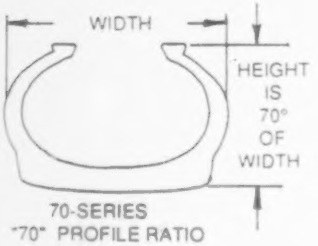
A. In order to understand tire sizing, it is first important to have an understanding of aspect ratio. Aspect ratio is the relationship of a tire's height to it's width. Another term for aspect ratio is profile or series. For example, a 70-series tire is 70% as tall as it is wide. The most common series are 60, 70, 75, and 80.



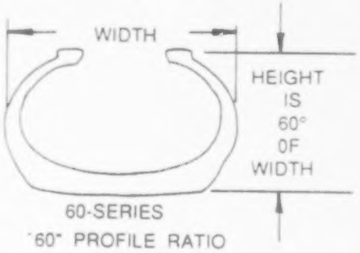
78 -SERIES
"78" PROFILE RATIO



75- SERIES
"75" PROFILE RATIO



70-SERIES
"70" PROFILE RATIO



60-SERIES
"60" PROFILE RATIO

B. Metric sizing of tires is widely used today. A typical P Metric size would be P225/75R15. Below is an explanation of the letters and numbers that might appear on a typical metric tire size.

P = passenger car tire

225 = tread width in millimeters when mounted on the proper rim

75 = aspect ratio (series)

R = radial-ply construction

15 = rim diameter in inches

C. Alpha numeric sizing was once the accepted standard by which tires were sized. The alpha numeric system was eventually replaced by metric sizing. A typical alpha numeric size would be FR70-15. Below is an explanation of what the letters and numbers mean.

F = size range

R = radial-ply construction

70 = aspect ratio

15 = rim diameter in inches

D. Most tires sold today are of the metric size designation. Conversion charts are used to determine which sizes are comparable.

IX. A convenience (space saver) spare tire is a small tire mounted on a special narrow rim. The space saver spare tire allows more space in the vehicle's luggage compartment than a full-size spare tire. Inflation pressure of convenience tires (usually less than that of standard tires) is molded into the tire sidewall. Some convenience spare tires will come with an aerosol bottle which is used for inflation.

(NOTE: The convenience spare tire and wheel are not interchangeable with the other tires and wheels on the vehicle.)

(**CAUTION:** A convenience tire is designed for use as a spare tire only. It should never be used as a replacement tire. A vehicle should be driven only short distances at reduced speeds when a convenience tire is being used.)

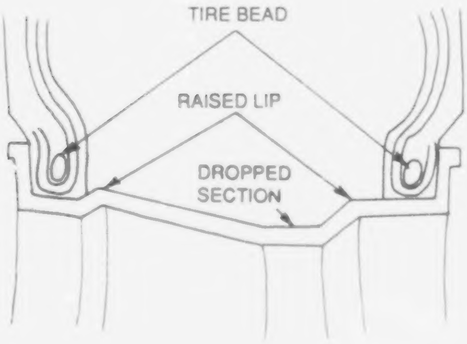
X. Wheels

A. Wheel construction

1. The common automobile wheel is made from stamped steel. The wheel consists of two pieces--the center and the rim. The center section is riveted or spot welded to the rim (the outer portion). The wheel has between four and six mounting holes for attaching the wheel to the wheel hub. The mounting holes are tapered to match tapered wheel nuts. The tapering helps to center the wheel on the wheel studs.

2. Most wheel rims are drop-center safety rims. Drop-center refers to the depression in the inner circumference of the rim. This depression allows one tire bead clearance while the other bead is being stretched over the rim.

3. Safety wheels have a raised lip inboard of each bead seat. This lip helps to prevent the bead from unseating if the vehicle corners hard or if the tire goes flat while the vehicle is moving.

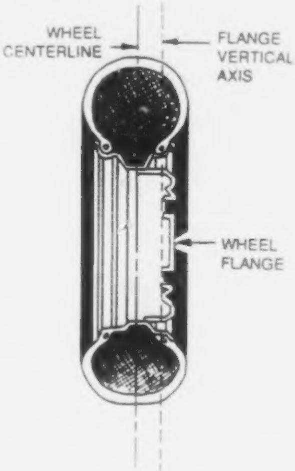


4. A hole in the rim accepts the tire valve stem. Air is added to or removed from the tire through the valve stem and core. The valve stem may be made of rubber, in which case it snaps into the hole. The stem may also be made of metal and held in place with a nut. The valve stem is located inside the valve core.

B. Wheel offset

1. Factory-installed wheels are designed with proper clearance for brake and suspension components. These wheels are also designed to distribute vehicle load evenly on the wheel bearings. Offset is the relationship between the vertical center line of the rim and the mounting flange of the wheel center. Usually the center line of the rim is inboard of the wheel's true centerline.

2. When replacing a wheel or installing an aftermarket wheel, use a wheel that has the same offset as the original. Many aftermarket wheels have an offset different from the original factory wheel. A difference in offset can affect wheel alignment, which, in turn, can affect handling and tire wear. A difference in offset can also affect weight distribution, causing premature failure of wheel bearings and spindles.



MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XV: WHEELS AND TIRES

LESSON 2: TIRE INSPECTION AND ROTATION

I. Tire inspections

A. Inflating tires

1. Every tire should be inflated to the factory-recommended pressure. The recommended tire pressures for a vehicle's original tires can be found on a decal, which is usually located either on the rear face of the driver door or the owner's manual. However, if the original tires have been replaced, it is recommended that the tire be inflated to the tire manufacture's specification. The tire manufacturer stamps the correct air pressure range on the sidewall of the tire.

2. Tire pressure should be checked while the tires are cool (at 50°F to 70°F). The tires will usually be sufficiently cool after the car has been immobile for about three hours or if the car has been driven less than one mile.

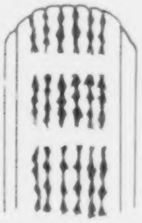
   (NOTE: Tire pressures can increase as much as 6 psi when the tires become hot.)

3. Inflation pressure should be tested with a pencil-type tire gauge at least once a month or before a long trip. The spare tire should also be checked. Stem caps should be reinstalled after pressures are checked. If stem extensions are used, make sure they are in place. If stem caps and valves are not in place, dirt and moisture may enter the valve core, causing leaks.

B. Procedure for checking tire wear and condition

1. Carefully raise and support the vehicle on a hoist.

2. Most tires have built-in tread wear indicators, which appear as 1/2" wide bands when the tread is worn to 1/16". If the indicators appear in two or more adjacent grooves at three or more locations around the tire, the tire should be replaced.



3. Inspect tires for exposed tread fabric. Replace any tire that has worn through the tread.

4. Inspect tires for lumps or knots caused by broken or damaged tire plies. Replace tires which have such lumps or knots.

5. Inspect tires for deep cuts--especially cuts that expose the fabric. Replace any tire that has deep cuts.

6. Inspect tires for flat spots on the tread surface. Flat spots are caused by hard brake applications at high speeds or defective tire construction. Tires with flat spots must be replaced.

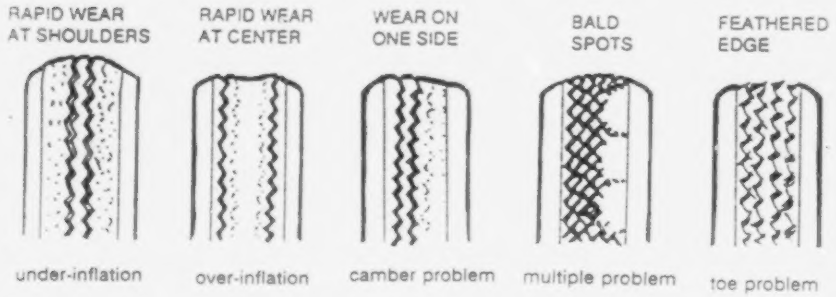
7. Inspect tires for foreign objects (nails, screws, etc.) which have penetrated the tire. If found, the tire must be repaired or replaced.

8. Inspect tires for missing valve stem caps or extensions. If missing, they should be replaced.

9. Inspect tires for signs of tread separation. Separations will resemble blisters on the tire's tread or sidewall.

10. Inspect tires for broken or bent wheels. If damage is found, the wheel must be replaced. To ensure the wheel is straight, spin each tire and wheel assembly by hand and watch for excessive runout (wobble).

11. Inspect tires for abnormal wear caused by improper wheel alignment. The illustration below shows various tire conditions and their possible causes.



II. Procedures for removing the tire and wheel assembly

A. Remove the wheel cover. Using a suitable prying tool, carefully pry off the wheel cover.

(NOTE: If the wheel is equipped with a locking-type wheel cover, remove the trim cover from the lock bolt. Next, use a special wheel bolt wrench to remove the lock bolt.)

(**CAUTION:** Many wheel covers have very sharp metal edges. Handle wheel covers carefully to avoid injury.)

(NOTE: Take care not to damage the wheel cover during removal.)

(NOTE: The owner's manual should be consulted if wheel covers are difficult to remove.)

B. Loosen the lug nuts one turn.

(NOTE: Some vehicles are equipped with one antitheft lug nut on each wheel. A special socket or key must be used to remove the antitheft wheel nut.)

C. Safely raise the vehicle until the tires are off the floor; then secure the vehicle.

D. Remove the lug nuts and remove the wheel.

III. Procedures for installing tire and wheel assemblies

A. Clean dirt and corrosion from the wheel hub mounting area and from the center pilot hole of the wheel.

B. Place the wheel on the hub and install the lug nuts finger tight.

C. Using the proper wrench, tighten the nuts alternately to draw the wheel evenly against the hub.

D. Lower the vehicle and finish tightening the lug nuts to the manufacturer's specified torque.

E. Install the wheel cover. Hit the cover only around the outer circumference with a soft rubber mallet.

IV. Rotating the tires

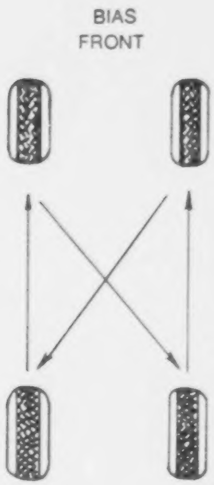
A. Rotating tires involves moving the tire to a different location on the vehicle. Since tires wear differently and at different rates, they should be rotated every 7500 miles or at intervals specified by the tire manufacturer.

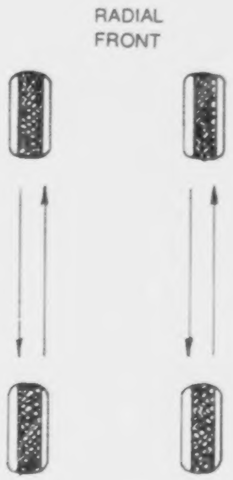
(**CAUTION:** If abnormal tire wear is discovered during rotation, the cause should be corrected before the rotation is complete.)

(NOTE: The spare tire may be included in the rotation if it is a full-size tire. Do not include convenience spare tires in the rotation.)

B. Procedures for rotating tires

(NOTE: Tires can be rotated in various patterns; however, the rotation pattern must meet the tire manufacturer's recommendation. For example, some radial tires are unidirectional--that is, their rotation pattern will resemble more closely the bias rotation pattern than a typical radial rotation pattern.)





1. Loosen tire and wheel assemblies as described earlier in this lesson.
2. Safely raise and support the vehicle so that all four wheels are off the ground.
3. Rotate the tire and wheel assembly in the chosen pattern.
4. Tighten all lug nuts evenly. Make sure to tighten them to the recommended torque.

   (**CAUTION**: Some tires are directional--that is, they have a special tread designed to roll in only one forward direction--and may not be crossed from one side of the vehicle to the other. This type of tire normally has an arrow molded into the sidewall, indicating the direction of rotation.)

   (**CAUTION**: Some wheels are directional--that is, they can only be rotated in one direction--and cannot be moved from one side of the vehicle to the other. The purpose of directional wheels is to aid the cooling of the brakes.)

C. Convenience spare tires should never be included in tire rotation.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR ROTATING TIRES

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Determine the rotation pattern to be used. Make a drawing showing the pattern of tire rotation. Be sure to identify the front and rear of the vehicle.
3. Determine and record the lug nut torque sequence and the final torque specifications.

JS1-L2-UXV

MODULE: STEERING AND SUSPENSION SYSTEMS

INSPECTING AND INFLATING TIRES

Equipment:

Hoist
Pencil-type tire gauge
Serviceable vehicle
Safety glasses

Procedure: Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Place the vehicle securely on safety stands or safely lift it with a hoist. __ __ __ __

3. Visually inspect each tire for wear or damage. Record in the spaces below the results of the inspection. __ __ __ __

Is tread wear abnormal? YES____ NO____

Are there punctures? YES____ NO____

Are there lumps or knots? YES____ NO____

Are there exposed cords? YES____ NO____

Are the valve stems damaged? YES____ NO____

Are there flat spots? YES____ NO____

Are radial and bias tires on the same axle? YES____ NO____

Do the tire sizes vary? YES____ NO____

If YES was the answer to any of the above questions, describe the problem and suggest the appropriate action to be taken. If abnormal tread wear was noted during the inspection, be sure to identify the cause.

4. Spin each tire and wheel assembly while noting any wobble (lateral or radial runout). Record observations. — — — —

5. Determine the proper inflation pressure for the vehicle being inspected. Record the pressures in the spaces below. Lower the vehicle. — — — —

Cold inflation pressure

Front tires___________

Rear tires____________

Spare tire____________

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency U1. Final evaluation for U1 will be made at the end of JS1-L1-UXVII.)

JS2-L2-UXV

MODULE: STEERING AND SUSPENSION SYSTEMS

ROTATING TIRES

Equipment:

Hoist
Wheel wrench
Torque wrench
Hand tools
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. — — — —

2. Place the vehicle securely on safety stands or safely lift it with a hoist. — — — —

3. Complete AS1-L2-UXV. Following the pattern and specifications developed in items 2 and 3 of AS1-L2-UXV, rotate the vehicle's tires. — — — —

   a. Inspect the condition of the tires during the rotation. Record observations.

   b. Inspect the condition of the wheel studs and nuts. Record observations. Replace any defective wheel studs or nuts as directed by the instructor.

   c. Inflate all tires to the recommended pressure.

   d. Tighten all wheel nuts to the specified torque and lower the vehicle.

   (NOTE: To prevent rotor distortion, do not use an air wrench to replace lug nuts on hubs with disc brakes.)

   (NOTE: Use only a soft-faced rubber mallet to install the wheel covers.)

   Average of above evaluations* — — — —

   (*This average is a partial evaluation for Competency U4. Final evaluation for U4 will be made at the end of JS2-L2-UXVI.)

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XV: TIRES AND WHEELS

LESSON 3: TIRE MOUNTING AND PUNCTURE REPAIR

I. Procedures for dismounting tires

(NOTE: Dismounting or mounting tires should only be done with a tire machine. Using tire irons or pry bars to mount or dismount tires can damage tire beads.)

(NOTE: If the tire tread is directional, note the direction of the tread before mounting.)

A. Deflate the tire by removing the valve core with a valve core tool.

B. Using wheel weight pliers, remove all wheel weights.

C. Mount the [illegible] and wheel assembly securely on the tire changer according to the instructions provided by the manufacturer of the tire changer.

D. Break the beads loose from the rim according to the instructions provided by the manufacturer of the tire changer.

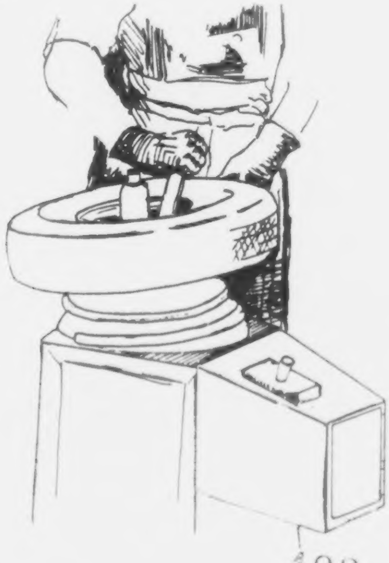
E. Lubricate both beads with a tire rubber lubricant or a mild soapy water solution to prevent bead damage and ease removal.

(NOTE: Do not use petroleum-based oil or silicone as a lubricant.)

F. Remove the tire beads according to the instructions provided by the manufacturer of the tire changer.

(**CAUTION:** Failure to follow the tire machine instructions carefully could result in serious personal injury.)

(NOTE: Do not force or allow the dismounting tool to hang up on the tire beads. Bead damage may result.)



II. Procedures for mounting tires

A. Clean the wheel. Both bead seats must be free of dirt and rust. Use a wire brush to clean the bead seats.

B. Inspect the wheel for damage.

(NOTE: Wheels that are cracked or obviously bent must be replaced. Wheels that are suspected of being bent or distorted should be tested for excessive runout. The procedure is discussed later in this module.)

C. Inspect the valve stems according to the procedure outlined below.

1. Bend rubber valve stems from side to side and look for signs of deterioration or cracking.

2. If the stem is bad, replace it.

(NOTE: It is good practice to replace the valve stems when mounting new tires.)

3. Apply rubber lubricant to the new stem and pull it through the hole in the rim. (A special tool is made for this purpose.)

D. Inspect the tire to be mounted according to the procedure outlined below.

1. Inspect the condition of the tire beads. Tires with badly torn or damaged beads should be discarded.

2. Inspect for punctures or damage to the tire tread or sidewall.

3. Clean any foreign material from inside the tire.

E. Lubricate both tire beads with rubber lubricant or a mild soapy water solution.

(**CAUTION**: Inadequate lubrication can damage beads or make installation and bead seating difficult. Too much lubrication can cause the tire to slip on the rim.)

F. Following the instructions provided by the manufacturer of the tire changer, mount the tire on the wheel.

G. Inflate and inspect the tire according to the procedure outlined below.

1. Inflate the tire until both beads pop out on the rim. Do not allow pressure to exceed 25 psi. Popping out beads at pressures over 25 psi can damage the rim. If the tire continues to inflate but will not pop, do not continue to add air. Deflate the tire and break and relube the beads before continuing.

(**CAUTION:** Keep fingers out and away from the bead seating area while popping the beads up.)

2. After the beads have popped, continue to inflate the tire to 40 psi. Passenger car tires should never exceed 40 psi.

(NOTE: This additional pressure helps to seat the beads properly on the rim.)

3. Install the valve core and inflate tire to the recommended pressure.

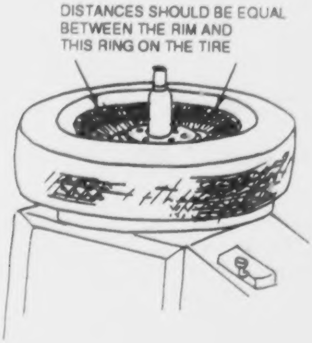
4. Place some soapy water in the valve stem at the valve core. Bubbles in the water indicate leaks.

   (NOTE: Leaks around the valve core are not uncommon. If leaks are discovered, loosen the valve core. Retighten and recheck the core. If it still leaks, replace the valve core and recheck for leakage.)

5. Install the valve stem cap or valve stem extension.

H. Visually inspect the tire for uneven bead seating.

(NOTE: The distance from the edge of the rim to the concentric rim locating ring should be equal around the circumference of the tire. A tire that is not concentric with the rim cannot be balanced accurately and may have excessive runout, both of which will result in unacceptable performance. If the wheel and tire are not concentric, deflate the tire and break and reseat the beads.)



(NOTE: The concentric rim locating ring is molded into the tire. The ring is visible just outside of the rim when the tire is mounted on the wheel.)

III. Procedures for repairing a tubeless tire

(NOTE: Steps A-F deal with all tire repairs. Step G deals with the patch-plug method and step H deals with the patch method.)

(**CAUTION:** Plug repairs or aerosol sealants provide only temporary repair. Permanent tire repairs can be achieved only by using one of the procedures outlined below.)

A. If a tire is suspected of having a leak, inflate the tire to the maximum recommended pressure and either immerse the tire in a tank of water or apply a soapy water to all areas of the tire. In either case, bubbles will appear at the leak.

(NOTE: In addition to the tire, valve stems, valve cores, and wheels are sometimes the cause of leakage.)

B. After the puncture is located, mark the hole with a tire crayon and then dismount the tire.

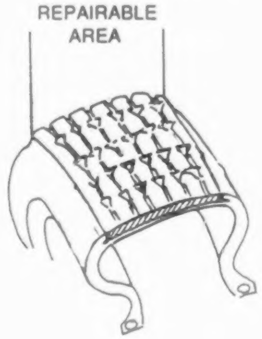
C. Remove the foreign object that caused the puncture (if the object is still in the tire).

D. Mount the tire in a tire spreading tool.

E. Inspect the tire for damaged beads. Tires with badly torn beads should be discarded.

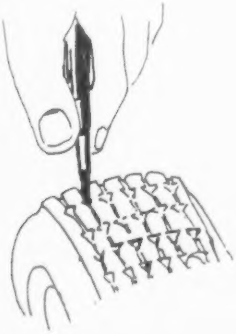
F. Inspect the tire for cuts, exposed cord, separations, etc. as described earlier in this unit.

(NOTE: Punctures and nail holes up to 1/4" diameter that are confined to the tread area may be repaired permanently only from inside the tire. Never repair tires worn below 1/16". The illustration below shows the normal repairable area of a tire.)

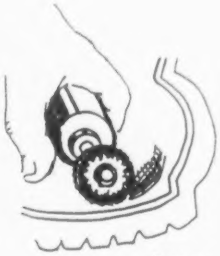


G. Installing a patch-plug

1. Clean out the puncture with a tungsten carbide rod tool.



2. Buff the area with a tungsten carbide buffing wheel driven by a 3/8" drill or pneumatic tool. Buff to achieve a finely grained bonding surface.

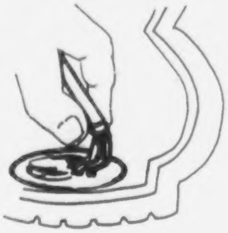


3. Do not burn the rubber with the buffing wheel. Do not buff until the cord body is exposed through the inner rubber lining.

4. Clean the buffing dust from the inside of the tire.

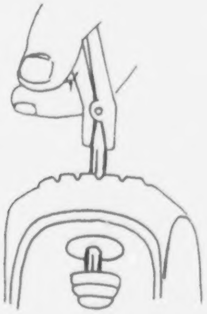
   (NOTE: Do not use petroleum solvent to clean the buffed area. Petroleum may neutralize the chemicals in the patching cement.)

5. Apply an even coat of patching cement to the puncture and the buffed area. Allow the cement to dry thoroughly.

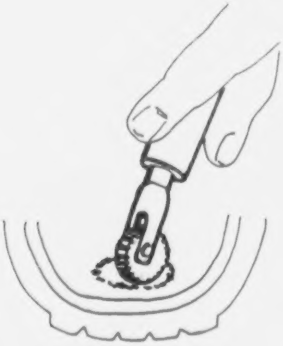


6. Select a patch plug which has a stem slightly larger than the puncture. Remove the protective backing from the patch plug.

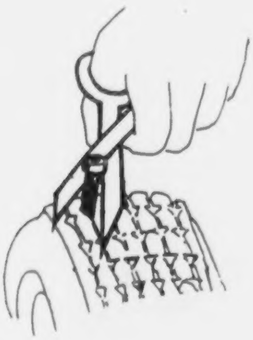
7. Coat the patch plug with cement and insert it through the puncture. A special installation tool may be used to pull the plug through the hole. Pull until the base of the patch presses against the tire.



8. Bond the patch firmly to the tire by rolling over the patch with a patch wheel. Keep strokes close together to avoid trapping air under the patch.



9. Cut off the protruding end of the plug approximately one-eighth of an inch above the tread surface.



10. Remount the tire and check the repair for leaks by either immersing it in a water tank or applying soapy water to the punctured area.

11. Rebalance the tire.

(NOTE: When repairing radial tires, use only patches or patch plugs which are designated for radial tires.)

H. Installing a tire patch

(NOTE: Follow procedures A-F as outlined above.)

(NOTE: Repairing a tire with a patch is similar to repairing it with a patch plug.)

1. Buff the inner surface of the tire in the same manner as described in the patch plug method. Clean the buffing dust from the tire.

2. Probe the tire to ensure nothing is still in the puncture.

   (**CAUTION**: Do not use a tungsten carbide rod as described in the patch plug procedure. Doing so will enlarge the puncture.)

3. Coat the buffed area with patching cement and allow it to dry.

4. Peel the protective backing from the patch and center it over the puncture. Bond the patch carefully to the tire.

5. Remount the tire and check the repair for leaks by either immersing it in a water tank or applying soapy water to the punctured area.

6. Rebalance the tire.

MODULE: STEERING AND SUSPENSION SYSTEMS

DISMOUNTING AND MOUNTING TIRES

Equipment:

Tire changer
Tire pressure gauge
Safety glasses

Procedure:

		Evaluation 3 2 1 N
1.	Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2.	If necessary, remove the tire and wheel assembly from the vehicle.	__ __ __ __
3.	Remove the valve core to deflate the tire.	__ __ __ __
4.	Remove any wheel weights from the wheel.	__ __ __ __
5.	Mount the tire on the tire machine and dismount the tire according to the machine's instructions.	__ __ __ __

(**CAUTION:** Failure to follow manufacturer's instructions when operating a tire machine could result in serious personal injury.)

(NOTE: In order to make bead removal easier and to prevent damage, apply rubber lubricant to both beads before dismounting.)

6.	Inspect the wheel and answer the following questions.	__ __ __ __

Is the rim damaged or bent? YES_____ NO_____

Are the rim bead seats rusted? YES_____ NO_____

Is the wheel broken or cracked? YES_____ NO_____

Is the valve stem in bad condition? YES_____ NO_____

If YES was the answer to any of the above questions, describe what action should be taken to correct the problem.

7. Following the procedure outlined below, inspect the tire to be mounted. ____

   a. Inspect the beads. If the beads are badly torn, the tire should be discarded.

   b. Check for any punctures in the tire. Repairable punctures should be patched before mounting. See JS2-L3-UXV for this procedure.

   c. Check for wear or damage to the tire tread or sidewall. Defective tires should be discarded.

   d. Check for and remove any foreign material from inside the tire.

   e. Record any problems found in the space below.

8. Clean the bead seating area of the rim prior to mounting the tire. Replace any defective tires, wheels, or valve stems as directed by the instructor. ____

9. Mount the tire on the wheel according to the tire machine manufacturer's instructions. ____

   a. Apply rubber lubricant to both beads before mounting.

      (**CAUTION:** Do not exceed 25 psi when popping the tire beads. Keep fingers clear of the tire when seating the bead on the rim.)

   b. Inflate to 40 psi to seat beads after beads have popped.

   c. Install the valve core and inflate to the specified pressure.

   d. Check for leaks at the valve core. Repair leaks if discovered.

   e. Install the valve stem cap or extension.

10. Reinstall the tire and wheel assembly on the vehicle, if required. ____

Average of above evaluations* ____

(*This average is a partial evaluation for Competency U4. Final evaluation for U4 will be made at the end of JS2-L2-UXVI.)

JS2-L3-UXV

MODULE: STEERING AND SUSPENSION SYSTEMS

REPAIRING PUNCTURES IN TUBELESS TIRES

Equipment:

Tire machine
Tire spreader
Tire pressure gauge
Tire buffer
Safety glasses

Procedure:		Evaluation 3 2 1 N
1.	Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2.	If required, remove the tire and wheel assembly from the vehicle.	__ __ __ __
3.	Locate and mark the puncture.	__ __ __ __
4.	Remove the foreign object causing the puncture.	__ __ __ __
5.	Dismount the tire. For this procedure, refer to JS1-L3-UXV.	__ __ __ __
6.	Mount the tire in a tire spreader and inspect the condition of the tire. Answer the questions below.	__ __ __ __

Is the puncture repairable? YES_____ NO_____

Is the bead in good condition? YES_____ NO_____

Is tire wear normal? YES_____ NO_____

Is the tire in good general condition? YES_____ NO_____

If NO was the answer to any of the above questions, describe the problem and recommend repairs.

7.	Determine and record below the type of repair to be made. Consult the instructor for directions.	__ __ __ __

8. Probe the puncture to make sure all foreign material is removed. — — — —

9. Following the procedure outlined below, repair the tire. — — — —

   a. Prepare the area to be patched according to the type of patch to be used.

   b. Remove all buffing dust from the tire.

   c. Apply tire patch cement and allow it to dry thoroughly.

   d. Install the patch and bond the patch to the tire.

   e. Cut off excess patch plug (if used).

10. Mount the repaired tire on the wheel. For this procedure, refer to JS1-L3-UXV. — — — —

11. Test the repair for leaks. Record the results in the space below. — — — —

12. Balance the tire. — — — —

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency U4. Final evaluation for U4 will be made at the end of JS2-L2-UXVI.)

MODULE: STEERING AND SUSPENSION

UNIT XV: WHEELS AND TIRES

UNIT XV TEST

PART I. BASIC TIRE DESIGN

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 1. Tires work to absorb shocks and provide traction.

____ 2. Tubeless tires are seldom used in today's cars and light trucks.

____ 3. Tire beads hold the tire in position on the rim.

____ 4. A tire belt improves tire wear and handling because it strengthens the tire sidewalls.

____ 5. Radial and bias tires should not be mixed.

____ 6. The National Highway Administration grades tires.

____ 7. Common automobile wheels are made from two pieces of stamped steel.

____ 8. Aspect ratio is commonly referred to as profile or series.

____ 9. Tire size markings may be alpha or metric.

____ 10. Tread wear indicators appear when tires are worn to 1/32".

SECTION B. Select the best answer from the five choices listed.

____ 11. Radial tires offer

- a. better traction.
- b. longer tread life.
- c. softer ride.
- d. increased fuel economy.
- e. all of the above.

____ 12. A vehicle should not be driven with both radial- and bias-ply tires on the same axle because

- a. radial- and bias-ply tires are never the same size.
- b. radial-ply tires set lower than bias-ply tires.
- c. bias-ply tires carry more weight than radial-ply tires.
- d. radial- and bias-ply tires have different handling characteristics.
- e. radial-ply tires cost more than bias-ply tires.

____ 13. The National Highway Safety Administration established quality standards for tire

a. speed.
b. temperature resistance.
c. traction.
d. tread wear.
e. all of the above.

____ 14. A tire with a traction rating of A will perform better than a tire rated C on

a. ice-covered pavement.
b. dry pavement.
c. wet pavement.
d. snow-covered pavement.
e. none of the above.

____ 15. Speed ratings designate

a. how long a tire can be driven over 100 mph.
b. how well a tire dissipates heat created during high speed driving.
c. the maximum speed at which a tire can be safely driven.
d. the maximum speed at which the tire can be safely driven on wet surfaces.
e. all of the above.

____ 16. Space saver spare tires should be

a. used as normal tires.
b. used only on compact cars.
c. run only a limited number of miles.
d. included in tire rotations.
e. inflated even when not in use.

____ 17. During normal driving, heat can cause tire air pressure to increase up to

a. 6 psi.
b. 12 psi.
c. 18 psi.
d. 24 psi.
e. none of the above.

____ 18. Rapid tire shoulder wear is caused by

a. alignment problems.
b. suspension problems.
c. under-inflation.
d. over-inflation.
e. manufacture's defect.

____ 19. Rapid wear at the tire tread center is caused by

a. alignment problems.
b. suspension problems.
c. balance problems.
d. under-inflation.
e. over-inflation.

____ 20. Bald spots on the tread are usually caused by

- a. tire defects and tire imbalance.
- b. worn suspension or poor alignment.
- c. over-inflation.
- d. under-inflation.
- e. multiple problems.

____ 21. A feathered edge on the tire tread indicates

- a. poor driving habits.
- b. incorrect toe.
- c. incorrect caster.
- d. wheel imbalance.
- e. tire defect.

____ 22. Wear on one side of the tread indicates

- a. excessive caster.
- b. excessive camber.
- c. excessive toe.
- d. over-inflation.
- e. under-inflation.

____ 23. If abnormal tire wear is found,

- a. replace the tires.
- b. rotate the tires.
- c. repair the problem.
- d. sell the vehicle.
- e. do none of the above.

____ 24. When tire tread wear indicators appear in two or more adjacent grooves at three or more locations, the tire should be

- a. repaired.
- b. replaced.
- c. checked for leaks.
- d. rebalanced.
- e. deflated.

(NOTE: The student must obtain a minimum score of ____ on Part I of the Unit XV Test in order to receive an evaluation for Competency U1.)

PART II. TIRES SERVICE

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 25. During repair, tire punctures should be marked with tire crayon.

____ 26. One way of locating a leak in a tire is to immerse the tire in a tank of water.

____ 27. The patch plug method of tire repairs calls for the puncture to be cleaned out with a tungsten carbide rod tool.

____ 28. When repairing a tire with the patch plug method, the technician should select a patch plug with a stem slightly larger than the puncture.

____ 29. Wheel covers should be removed with a prying tool.

____ 30. Wheel covers should be installed with a soft rubber mallet.

____ 31. Some vehicles are equipped with antitheft lug nuts.

____ 32. Lug nuts should always be tightened to the manufacturer's specified torque.

____ 33. When installing a wheel cover, the cover should be hit in the center with a hammer.

____ 34. Tire rotation will prolong tire life.

____ 35. Tires must be rotated because different tires wear at different rates.

____ 36. Tires should be rotated every 7,500 miles or at an interval specified by the tire manufacturer.

____ 37. Tire rotation can include the spare tire if it is not a convenience spare.

____ 38. During rotation, radial tires should usually be kept on the same side of the vehicle (left-right) during rotation.

____ 39. Before a tire is dismounted, all the air and wheel weights should be removed.

____ 40. During bead removal, the beads should be lubricated once they are loosened from the rim.

____ 41. Before a tire is installed on a wheel, the wheel should be cleaned and inspected.

____ 42. Valve stems should be checked when mounting new tires on wheels.

____ 43. Hands and fingers should be kept clear of the tire and rim while the bead is being seated.

____ 44. The valve core should not be in the stem while the bead is being seated.

____ 45. Wheels are "drop centered" to allow the bead to be stretched onto the wheel.

(NOTE: The student must obtain a minimum score of ____ on Part II of the Unit XV Test in order to receive an evaluation for Competency U4.)

ANSWERS TO UNIT XV TEST

1. t
2. t
3. t
4. t
5. t
6. t
7. t
8. t
9. t
10. f
11. e
12. d
13. e
14. c
15. c
16. c
17. a
18. c
19. e
20. e
21. b
22. b
23. c
24. b
25. t
26. t
27. t
28. t
29. t
30. t
31. t
32. t
33. f
34. t
35. t
36. t
37. t
38. t
39. t
40. t
41. t
42. t
43. t
44. t
45. t

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVI: WHEEL RUNOUT AND BALANCE

UNIT OBJECTIVE

After completing this unit, the student will be able to test tire and wheel runout and perform static and dynamic balance on tire and wheel assemblies. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify the differences between static and dynamic balance (Competency U4, Unit XVI Test).

II. Identify the characteristics of wheel runout (Competency U4, Unit XVI Test).

Lesson 2. I. Identify the procedures for testing radial runout of wheel and tire assemblies (Competency U4, Unit XVI Test).

II. Identify the procedures for testing lateral runout of the wheel and tire assemblies (Competency U4, Unit XVI Test).

III. Identify the procedures for checking lateral and radial runout of the wheel assemblies (Competency U4, Unit XVI Test).

IV. Identify the procedures for match mounting a tire and wheel assembly (Competency U4, Unit XVI Test).

V. Identify the procedures for balancing tire and wheel assemblies (Competency U4, Unit XVI Test).

VI. Demonstrate the ability to:

a. Measure tire and wheel assembly for lateral and radial runout (Competency U1, JS1-L2-UXVI).

b. Balance tire and wheel assemblies (Competency U4, JS2-L2-UXVI).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks D069 and D071.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVI: WHEEL RUNOUT AND BALANCE

CONTENTS OF THE UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

- 1. Lesson 1: PRINCIPLES OF WHEEL BALANCE AND RUNOUT
  - a. Information outline
- 2. Lesson 2: TESTING FOR AND CORRECTING WHEEL ASSEMBLY RUNOUT AND IMBALANCE
  - a. Information outline
  - b. Assignment sheet

    AS1-L2-UXVI: Procedures for Measuring Wheel and Tire Assembly Runout
  - c. Job sheets

    JS1-L2-UXVI: Measuring Tire and Wheel Assembly Lateral and Radial Runout
    JS2-L2-UXVI: Balancing Tire and Wheel Assemblies

E. Unit test

F. Answers to unit test

REFERENCES

Buick Division, General Motors Corporation. 1982 Buick Chassis Service Manual. Buick Division, General Motors Corporation. 1981.

Chrysler Corporation. Service Manual, Rear Wheel Drive 1985 Passenger Cars. Chrysler Corporation. 1984.

Ford Motor Company. 1990 Mustang Car Shop Manual. Ford Motor Company. 1990.

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Ford Parts and Service Division. 1988 Car Shop Manual, Volume B. Ford Parts and Service Division. 1987.

Moog Automotive Inc. Moog Front End Service Manual, Inspection and Service Procedures . St. Louis, Missouri: Moog Automotive Inc. 1986.

Toboldt, William K. and Johnson, Larry. Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair. South Holland, Illinois: The Goodheart-Willcox Company, Inc. 1981.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L2-UXVI in conjunction with JS1-L2-UXVI and JS2-L2-UXVI.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVI: WHEEL RUNOUT AND BALANCE

LESSON 1: PRINCIPLES OF WHEEL BALANCE AND RUNOUT

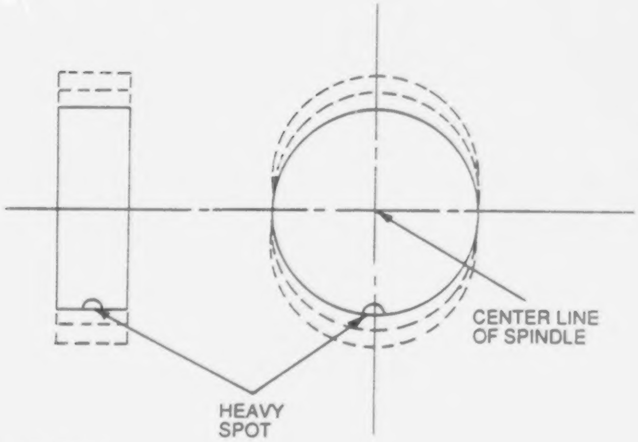
I. Static and dynamic balance

A. If a tire and wheel assembly is heavier at one point than another, the assembly is said to be out of balance. Imbalanced wheel assemblies result in a rough ride. Imbalanced wheel assemblies also shorten the life of the tires and damage steering and suspension components. Tires can be balanced by using either the static method or the dynamic method.

B. Static balance

1. Static balance means the weight of the tire and wheel assembly is distributed equally around the axis of wheel rotation (the spindle). If a tire and wheel assembly is in static balance, the wheel will have no tendency to rotate on its own, regardless of its position. If the tire and wheel assembly is not statically balanced, the assembly will roll on its own until the heavy spot is at the bottom.

2. A statically out-of-balance wheel assembly will tramp or hop as the car moves down the road. The speed at which the tramp occurs depends upon the degree to which the wheel is out of balance. The greater the imbalance, the lower the speed at which the tramp will be noticed.

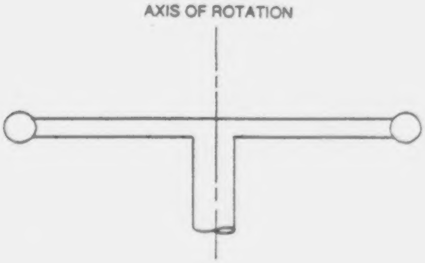


C. Dynamic balance

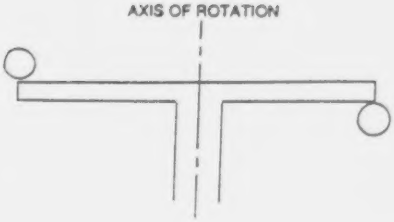
1. Dynamic balance can be defined as balance in motion. If a wheel assembly is in dynamic balance, it must also be in static balance. However, a wheel assembly that is balanced statically is not necessarily balanced dynamically.

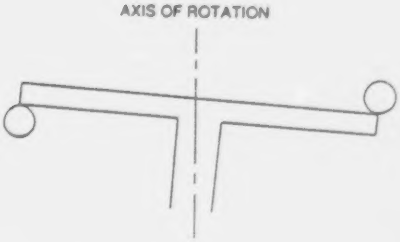
2. To achieve dynamic balance, weight must be distributed equally around the axis of rotation. Weight must also be distributed equally in regard to the centerline of the tire and wheel assembly. Listed below are some principles of dynamic balance.

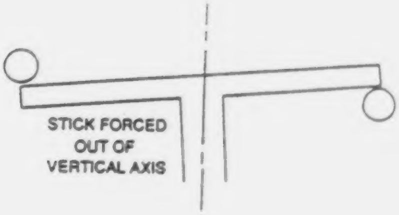
a. Imagine a stick with equal weights attached to each end. Imagine this same stick attached to a pivot as shown in the illustration below. If the stick were spun around, the path of its rotation would be at a right angle to the pivot (axis of rotation).

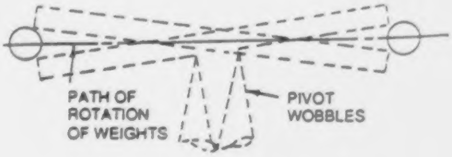

AXIS OF ROTATION

b. If the weights are shifted as shown in the illustration below, the stick will remain in static balance. However, if the stick is spun with the weights in their shifted position, the stick will be forced out of its axis of rotation due to dynamic imbalance. The stick will tend to wobble each half revolution due to the heavy weights, attempting to line up with the center of rotation.

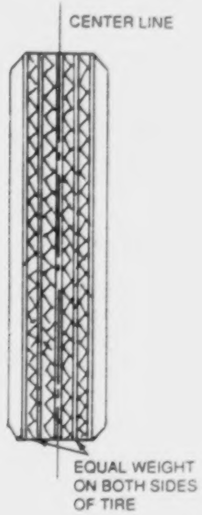

AXIS OF ROTATION


AXIS OF ROTATION


STICK FORCED
OUT OF
VERTICAL AXIS


PATH OF
ROTATION
OF WEIGHTS
PIVOT
WOBBLES

c. To compensate for this dynamic imbalance, weight must be placed equally around the centerline of the stick. In the case of an automobile wheel, the same is true: weights must be placed around the centerline of the tire as indicated in the illustration below.



d. Correcting the dynamic balance of the tire also corrects any static imbalance.

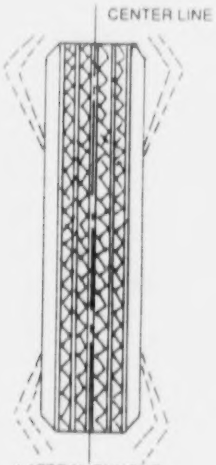
II. Wheel runout

A. When wheel tramp or vibration is evident, the cause must be determined before corrective action can be taken. In addition to improper balance, radial or lateral wheel runout may be causing the tramp or vibration.

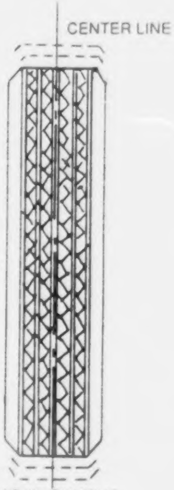
(NOTE: When wheel tramp or vibration is evident, it is advisable to check runout before balancing a wheel.)

B. A tire and wheel assembly with excessive radial runout is commonly referred to as being out of round. In a tire and wheel assembly with radial runout, the distance from the spindle to the ground changes as the assembly rotates, thus causing the assembly to hop or tramp.

C. Lateral runout is a sideways wobble of the tire and wheel assembly. The wobble occurs as the assembly rolls. Lateral runout is often referred to as shimmy. If the front wheels have lateral runout, the steering wheel may oscillate.



LATERAL RUNOUT



RADIAL RUNOUT

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVI: WHEEL RUNOUT AND BALANCE

LESSON 2: TESTING FOR AND CORRECTING WHEEL ASSEMBLY RUNOUT AND IMBALANCE

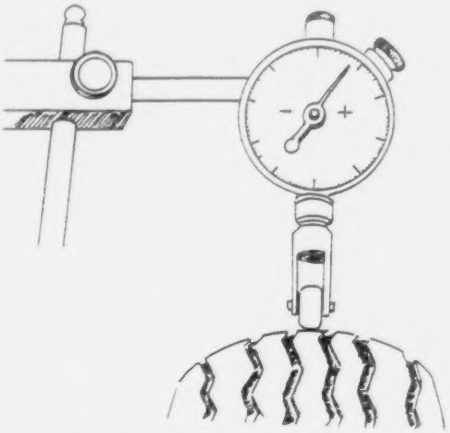
I. Procedures for testing the radial runout of the wheel and tire assembly (out of round)

(NOTE: Before testing runout, the vehicle should be driven in order to warm the tires and eliminate any irregularities that may have developed as a result of the vehicle being stationary.)

(NOTE: Check and, if necessary, correct wheel bearing adjustment.)

A. Safely raise and secure the vehicle. Make sure the tires are raised 3 to 4 inches off the floor.

B. Position the wheel and tire runout gauge (a dial indicator with a roller attached to the plunger) on the center rib of the tire.



C. Rotate the wheel one full revolution and zero the runout gauge at the low spot of the tire and wheel assembly.

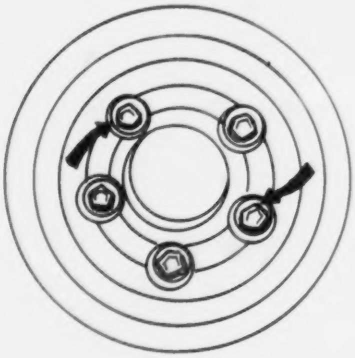
D. Rotate the wheel again and mark the high spot on the tread. Also mark the wheel bolt nearest the high spot on the tire.

(NOTE: The specification for radial runout is usually no more than .125 of an inch. Check the proper service manual for the vehicle to be serviced.)

E. If radial runout is within specifications, the radial runout test is complete and the lateral runout test can be performed. Refer to the information on lateral runout tests found later in this lesson.

F. If radial runout is not within specifications, perform the procedure outlined below.

1. Unbolt the wheel and rotate it two studs on the hub. Repeat steps C and D above.



2. If, after performing steps C and D above, runout is still excessive, mark the location of the new high spot on the tire. If this second high spot mark is near the first high spot mark, the runout is caused by either the wheel or the tire. In this case, the tire and wheel should be match mounted. (Refer to the match mounting information presented later in this lesson.) If the second high spot mark lines up with the first wheel stud mark, the hub or the hub assembly is defective and should be replaced.

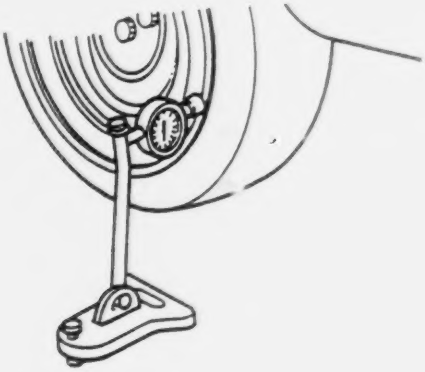
II. Procedures for testing the wheel and tire assembly for lateral runout (wobble)

(NOTE: Before testing runout, the vehicle should be driven in order to warm the tires and eliminate any irregularities that may have developed as a result of the vehicle being stationary.)

(NOTE: Check and, if necessary, correct wheel bearing adjustment.)

A. Safely raise and secure the vehicle. Make sure the tires are raised 3 to 4 inches off the floor.

B. Position the wheel and tire runout gauge (a dial indicator with a roller attached to the plunger) on the tire sidewall. Make sure it is as close to the tire shoulder as possible without interference from the markings on the outside of the tire.



C. Rotate the wheel one revolution. Mark the low spot on the tire and zero the gauge.

D. Rotate the wheel again and mark the high spot on the tread. Also mark the wheel bolt nearest the high spot on the tire.

(NOTE: The specification for lateral runout is usually no more than .060 of an inch. Check the proper service manual for the vehicle to be serviced.)

E. If lateral runout is within specifications, the lateral runout test is complete.

(NOTE: If both radial and lateral runout are within specifications, the wheel and tire assembly should be balanced.)

F. If lateral runout is not within specifications, perform the procedure outlined below.

1. Unbolt the wheel and align the low spot mark on the tire as closely as possible to the wheel bolt that was marked as the high spot in step D above.

2. Repeat steps C and D above.

3. If, after performing steps C and D above, lateral runout is still excessive, mark the location of the new high spot on the tire. If this second high spot mark is near the first high spot mark, the runout is caused by either the wheel or the tire. In this case, the tire and wheel should be match mounted. (Refer to the match mounting information presented later in this lesson.) If the second high spot mark is near the low spot marked in the first observation, the hub or hub assembly is defective and should be replaced.

III. Procedures for checking the wheel for lateral and radial runout

A. Remove the wheel from the vehicle and dismount the tire.

B. Reinstall the wheel on the vehicle and tighten wheel nuts evenly to the specified torque.

C. Place the dial indicator on the vertical and horizontal bead seats and measure the lateral runout and then the radial runout while rotating the wheel.

D. If the runout is excessive when compared to specifications, replace the wheel.

(NOTE: The specification for wheel lateral and radial runout is usually half the wheel/tire specified tolerance.)

IV. Procedures for match mounting a tire and wheel assembly

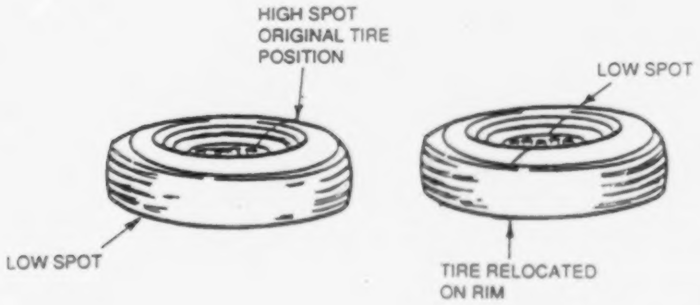
(NOTE: The procedure for match mounting a tire and wheel assembly is the same for correcting both radial and lateral runout.)

A. Mark the runout high spot on the wheel and tire.

B. Using a tire machine, deflate the tire and break the beads loose.

C. Measure the lateral and radial runout of the wheel as described earlier in this lesson. If the wheel is defective, replace it.

D. Rotate the tire on the rim 180 degrees from its original position. Inflate the tire to the specified pressure.



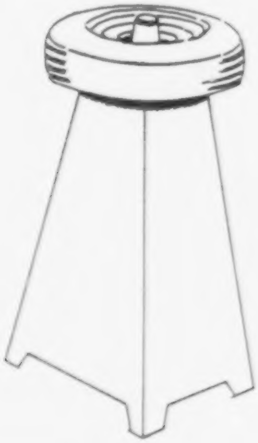
E. Install the wheel on the vehicle and recheck the runout. If runout is within specifications, proceed with balancing the tire. If runout is still excessive, the tire must be replaced.

V. Balancing a wheel

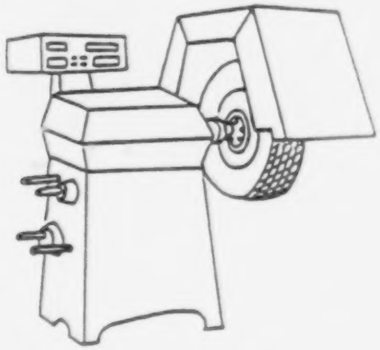
A. Wheel imbalance is corrected by determining the location of the imbalance and then determining where to place weights to correct the imbalance.

B. Two types of wheel balancers are the bubble balancer and the off-vehicle computerized balancer.

1. The bubble balancer works much like a carpenter's level. If the tire has a heavy spot, the balancer will tilt and throw the bubble off center. (Off center is indicated by the bubble moving out of a circle on the balancer.) Weight is then applied at various positions on the tire. When the proper amount of weight is added at the proper locations, the bubble moves back into the center of the circle. A bubble balancer can achieve only a static balance.



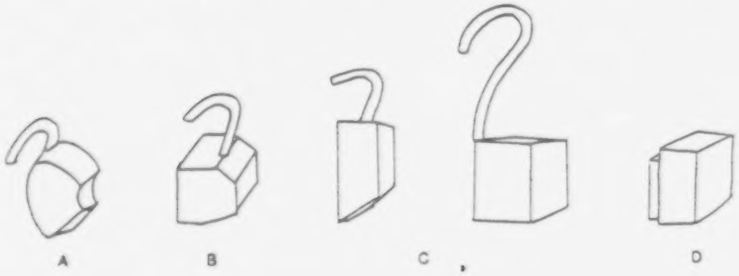
2. An off-vehicle computerized balancer is the most commonly used balancer today. The computerized balancer is simple to operate and achieves a high degree of accuracy. This type of balancer corrects both static and dynamic imbalance. After spinning the tire and wheel assembly, the balancer indicates how much weight is needed and where the weight should be placed.



C. Wheel weights

1. Wheel weights are made of lead. Wheel weights range from 1/4 ounce to several ounces. Wheel weights are usually marked in both ounces and grams.

2. Wheel weights are usually attached to the rim by steel clips, which are molded into the lead weight. Stick-on weights are also available for custom wheels. The illustration below shows some of the various types of weights available.



D. Procedure for balancing wheels

1. Before balancing tires with any type of balancer, clean any foreign material from the tire tread and wheel assembly. Even small pebbles can affect wheel balance.

2. Inspect the tire condition. Discard tires with tread worn to 1/16 inch or less. Also discard tires with bulges, separations, or other obvious damage.

3. Remove all old wheel weights.

4. Balance the wheel according to the directions provided by the manufacturer of the balancer.

5. Install weights securely on the wheel. Loose weights can fly off while the car is moving.

6. Recheck wheel balance after weights are installed.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR MEASURING WHEEL AND TIRE ASSEMBLY RUNOUT

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Determine and record the maximum allowable radial and lateral runout for the tire and wheel assembly being tested.
3. Determine and record the maximum allowable radial and lateral runout for the wheel after the tire is dismounted.

MODULE: STEERING AND SUSPENSION SYSTEMS

MEASURING TIRE AND WHEEL ASSEMBLY LATERAL AND RADIAL RUNOUT

Equipment:

Dial indicator
Serviceable vehicle
Tire machine
Safety glasses

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	_ _ _ _
2. After obtaining permission from the instructor, drive the vehicle to warm the tires and eliminate flat spots.	_ _ _ _
3. Place the vehicle securely on safety stands or safely lift it with a hoist.	_ _ _ _
4. Check and correct wheel bearing adjustment (when applicable).	_ _ _ _
5. Test radial runout of the tire and wheel assembly.	_ _ _ _

   a. Position a runout gauge on the center rib of the tire.

   b. Rotate the wheel one full revolution. Zero the runout gauge at the low spot of the tire and wheel assembly.

   c. Rotate the wheel again and mark the high spot on the tread. Also mark the wheel bolt nearest the high spot. Record runout below. Compare runout to the specification recorded in item 2 of AS1-L2-UXVI. If runout is within acceptable limits, go to item 7 of this job sheet. If runout is not within acceptable limits, go to item 6 below.

   Radial runout ____________

6. Unbolt the wheel and rotate it two studs on the hub. Repeat steps 5 a, b,and c above. If runout is still excessive, mark the location of the high spot. Answer the questions below.	_ _ _ _

   a. Is the new mark near the high spot marked in c of item 5 above?

   YES_____ NO____

b. Does the new mark line up with the wheel stud mark?

YES____ NO____

c. Based on the results of step 6, indicate which corrective procedures (if any) should be performed.

Corrective action needs to be taken.

YES____ NO____

Match mounting should be performed.

YES____ NO____

(NOTE: If match mounting must be performed, proceed to item 7 below.)

7. Following the procedure outlined below, match mount the wheel and tire assembly. ____

a. Mark the runout high spot on the wheel and tire.

b. Using a tire machine, deflate the tire and break the beads loose.

c. Measure the lateral and radial runout of the wheel as described earlier in this lesson. If the wheel is defective, replace it.

d. Rotate the tire on the rim 180 degrees from its original position. Inflate the tire to the specified pressure.

e. Install the wheel on the vehicle and recheck the runout. If runout is within specifications, proceed with balancing the tire. If runout is still excessive, the tire must be replaced.

f. Record the results of the match mounting procedure below.

8. Test the tire and wheel assembly for lateral runout. _ _ _ _

   a. Place the runout gauge on the tire sidewall as close to the tire shoulder as possible.

   b. Rotate the wheel one revolution. Mark the low spot on the tire and zero the gauge.

   c. Rotate the tire again. Mark the high spot on the tire. Also mark the lug bolt nearest the high spot. Read and record the lateral runout in the space below.

      Lateral runout________________

   d. Compare the lateral runout recorded above to the specification recorded in item 2 of AS1-L2-UXVI. If runout is within specification, this job sheet is complete. If runout is not within specification, go to step 9.

9. Unbolt the wheel and align the low spot mark with the marked wheel stud. Repeat steps 8 a, b, and c. If runout is still excessive, mark the position of the high spot and answer the below questions. _ _ _ _

   a. Is the marked wheel stud near the low spot marked in step b of item 8 above?

      YES_____ NO_____

   b. Is the marked wheel stud near the high spot marked in step c of item 8 above.

      YES_____ NO_____

   c. Based on the answers to questions a and b above, should the wheel hub and axle be either repaired or replaced?

      YES_____ NO_____

      Average of above evaluations* _ _ _ _

      (*This average is a partial evaluation for Competency U1. Final evaluation for U1 will be made at the end of JS1-L1-UXVII.)

MODULE: STEERING AND SUSPENSION SYSTEMS

BALANCING TIRE AND WHEEL ASSEMBLIES

Equipment:

Static/Dynamic wheel balancer
Wheel weight pliers
Safety glasses

Procedure:

		Evaluation 3 2 1 N
1.	Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2.	Place the vehicle securely on safety stands or safely lift it with a hoist.	__ __ __ __
3.	Following the procedure developed in JS1-L2-UXVI, test the lateral and radial runout of the tire and wheel assembly to be balanced. Record the test results and compare them to the tire and wheel runout specifications recorded in item 2 of AS1-L2-UXVI. Is the tire and wheel runout within specifications?	__ __ __ __

YES_____ NO______

(NOTE: Excessive tire and wheel runout should be corrected before attempting to balance the tires. Consult the instructor if excessive runout is found.)

4.	Inspect tire condition. Record any excessive wear or defects below.	__ __ __ __
5.	Balance the tire and wheel assembly according to the instructions provided by the manufacturer of the balancer. Be sure to include the below steps in the balancing procedure.	__ __ __ __

a. Remove any pebbles or foreign material lodged in the tire tread and wheel assembly.

b. Remove old wheel weights.

c. Install weights securely.

d. Recheck balance after weights are installed.

JS2-L2-UXVI

6. Reinstall the tire and wheel assembly on the vehicle. Tighten wheel nuts to the specified torque. Lower vehicle. — — — —

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency U4. Final evaluation for U4 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency U4 by averaging the evaluations of JS2-L2-UXV, JS1-L3-UXV, JS2-L3-UXV, and JS2-L2-UXVI. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS2-L2-UXV	—	—	—	—
JS1-L3-UXV	—	—	—	—
JS2-L3-UXV	—	—	—	—
JS2-L2-UXVI	—	—	—	—
Final evaluation for Competency U4	—	—	—	—

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVI: WHEEL RUNOUT AND BALANCE

UNIT XVi TEST

SECTION A. **Read the statements below. Place a T or an F in the blank beside each statement to indicate whether it is true or false.**

____ 1. Tire imbalance can shorten the life of suspension and steering components.

____ 2. Dynamic balance can be defined as balance in motion.

____ 3. Static imbalance will cause the vehicle to shimmy.

____ 4. The greater the static imbalance, the lower the speed at which wheel tramp will occur.

____ 5. If a wheel is in static balance, it will also be in dynamic balance.

____ 6. Dynamic balance refers to a tire being balanced in regard to the centerline of the tire and wheel assembly.

____ 7. Improper wheel balance is only one possible cause of vibration or wheel tramp.

____ 8. Wheel runout should be checked before the tire and wheel assembly is balanced.

____ 9. A tire and wheel assembly that has excessive lateral runout is commonly referred to as being out of round.

____ 10. Excessive lateral runout can cause wheel tramp or hop.

____ 11. Excessive radial runout will cause a wheel and tire assembly to wobble sideways.

____ 12. Radial runout at the front wheels will cause the wheel to vibrate back and forth.

____ 13. The two general categories of wheel balance are spin and static balance.

____ 14. Wheel and tire imbalance can cause a vehicle to ride roughly.

____ 15. Wheel bearing adjustment must be correct before runout checks are to be performed.

____ 16. A runout gauge is a special type of micrometer with a roller attached.

____ 17. Excessive radial wheel and tire runout should be corrected by match mounting the wheel and tire.

____ 18. Lateral runout testing is sometimes called out of round testing.

____ 19. Wheel lateral and radial runout tests cannot be performed with the tire off the wheel.

____ 20. Before performing match mounting, the technician should always balance the wheel and tire assembly.

____ 21. Match mounting should be done only if the wheel cannot be balanced.

____ 22. Improper wheel balance problems can cause excessive tread wear.

____ 23. Wheel and tire radial runout checks are affected by lug nut torque.

____ 24. Runout checks should be performed before wheel balance tests.

____ 25. If match mounting cannot cure a runout problem, either the wheel or tire needs to be replaced.

____ 26. Before wheel lateral and radial runout are tested, the tires should be warm.

____ 27. Wheel imbalance is often corrected by removing rubber from the tire.

____ 28. A bubble balancer works much like a carpenter's level.

____ 29. The bubble balancer can correct static and dynamic imbalance.

____ 30. Wheel weights are usually made of zinc.

SECTION B. **Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 31. **TECHNICIAN I says to make sure that the tire and wheel assemblies are free from any foreign materials or old weights before balancing the tires.**

TECHNICIAN II says that tires with less than 1/16 inch of tread should not be balanced.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 32. TECHNICIAN I says that tires with any deformities such as bulges or separations should be discarded.

TECHNICIAN II says that balancing weights are usually clipped onto the tires or stuck to the wheels.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 33. TECHNICIAN I says that wheel weights should be placed loosely on the wheel.

TECHNICIAN II says that most tire weights are marked in ounces and grams.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 34. TECHNICIAN I says that a bubble balancer works much like a carpenter's level.

TECHNICIAN II says that a computer balancer can correct both static and dynamic imbalance.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I nor II

___ 35. TECHNICIAN I says that the bubble balancer is the most widely used balancer today.

TECHNICIAN II says that a computer balancer will tell the mechanic where and how much weight to place on an out-of-balance wheel.

Who is right?
(a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of _____ on the Unit XVI Test in order to receive an evaluation for Competency U4.)

ANSWERS TO UNIT XVI TEST

1.	t
2.	t
3.	f
4.	t
5.	f
6.	t
7.	t
8.	t
9.	f
10.	f
11.	f
12.	f
13.	f
14.	t
15.	t
16.	t
17.	t
18.	f
19.	f
20.	f
21.	f
22.	t
23.	t
24.	t
25.	f
26.	t
27.	f
28.	t
29.	f
30.	f
31.	c
32.	c
33.	b
34.	c
35.	c

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVII: WHEEL ALIGNMENT AND STEERING AND SUSPENSION DIAGNOSIS

UNIT OBJECTIVE

After completing this unit, the student should be able to correct all adjustable alignment angles on front and rear suspensions and diagnose problems related to steering, suspension, wheel alignment, and balance. The student will demonstrate mastery of the material by achieving a score of _______ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the causes of vibration at highway speeds (Competency U1, Part I of the Unit XVII Test).

II. Identify the characteristics and causes of wheel shimmy (Competency U1, Part I of the Unit XVII Test).

III. Identify the characteristics of rough or damaged wheel bearings (Competency U1, Part I of the Unit XVII Test).

IV. Identify the characteristics and causes of wander (Competency U1, Part I of the Unit XVII Test).

V. Identify the characteristics and causes of lateral pull (Competency U1, Part I of the Unit XVII Test).

VI. Identify the characteristics and causes of hard steering (Competency U1, Part I of the Unit XVII Test).

VII. Identify the characteristics and causes of poor steering return (Competency U1, Part I of the Unit XVII Test).

VIII. Identify the procedures for diagnosing wheel shimmy, vibration, wander, pull, and bearing noise during a road test (Competency U1, Part I of the Unit XVII Test).

IX. Demonstrate the ability to:

  a. Road test a vehicle for steering, suspension, and wheel alignment problems (Competency U1, JS1-L1-UXVII).

Lesson 2.

I. Identify the characteristics of wheel alignment (Competencies U2 and U3, Parts II and III of the Unit XVII Test).

II. Identify the various wheel alignment angles (Competencies U2 and U3, Parts II and III of the Unit XVII Test).

Lesson 3.

I. Identify the various types of wheel alignment equipment (Competencies U2 and U3, Parts II and III of the Unit XVII Test).

II. Identify the procedures for making pre-alignment checks (Competencies U2 and U3, Parts II and III of the Unit XVII Test).

III. Identify the manner in which wheel alignment angles are interrelated (Competencies U2 and U3, Parts II and III of the Unit XVII Test).

IV. Identify the procedures for adjusting front-wheel camber (Competency U2, Part II of the Unit XVII Test).

V. Identify the procedures for adjusting front-wheel caster (Competency U2, Part II of the Unit XVII Test).

VI. Identify the procedures for adjusting front-wheel toe (Competency U2, Part II of the Unit XVII Test).

VII. Identify the procedures for rear-wheel alignment (Competency U3, Part III of the Unit XVII Test).

VIII. Identify concepts relating to four-wheel alignment (Competency U2 and U3, Parts II and III of the Unit XVII Test.)

IX. Demonstrate the ability to:

   a. Measure and correct front-wheel alignment (Competency U2, JS1-L3-UXVII).

   b. Measure and correct rear-wheel alignment (Competency U3, JS2-L3-UXVII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks cover ASE tasks D053-D064 and D070.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVII: WHEEL ALIGNMENT AND STEERING AND SUSPENSION DIAGNOSIS

CONTENTS OF THE UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: DIAGNOSING VARIOUS STEERING, SUSPENSION, AND WHEEL ALIGNMENT PROBLEMS

   a. Information outline

   b. Assignment sheet

      AS1-L1-UXVII: Diagnosing Various Steering, Suspension, and Wheel Alignment Problems

   c. Job sheet

      JS1-L1-UXVII: Road Testing a Vehicle for Steering, Suspension, and Wheel Alignment Problems

2. Lesson 2: PRINCIPLES OF WHEEL ALIGNMENT

   a. Information outline

   b. Assignment sheet

      AS1-L2-UXVII: Wheel Alignment Principles

3. Lesson 3: MEASURING AND CORRECTING WHEEL ALIGNMENT

   a. Information outline

   b. Assignment sheets

      AS1-L3-UXVII: Procedures for Measuring and Correcting Front-Wheel Alignment
      AS2-L3-UXVII: Procedures for Measuring and Correcting Rear-Wheel Alignment

   c. Job sheets

      JS1-L3-UXVII: Measuring and Correcting Front-Wheel Alignment
      JS2-L3-UXVII: Measuring and Correcting Rear-wheel Alignment

E. Unit test

F. Answers to unit test

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NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UXVII and AS2-L2-UXVII before taking the Unit XVII Test. Students should do AS1-L3-UXVII in conjunction with JS1-L3-UXVII and AS2-L3-UXVII in conjunction with JS2-L3-UXVII.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVII: WHEEL ALIGNMENT AND STEERING AND SUSPENSION DIAGNOSIS

LESSON 1: DIAGNOSING VARIOUS STEERING, SUSPENSION, AND WHEEL ALIGNMENT PROBLEMS

I. Sometimes a vehicle will vibrate at highway speeds. Some of the causes of vehicle vibration are listed below.

    A. Poor road surface

    B. Tire and wheel imbalance

    C. Bent wheels or excessive radial or lateral runout

    D. Defective tires

    E. Improper tires for the vehicle

    F. Drive line imbalance

    G. Engine imbalance

    H. Dragging or sticking brakes

II. Wheel shimmy is the shaking of the front wheels. Wheel shimmy usually begins at a lower speed than other types of vehicle vibration. The shimmy is usually transferred through the steering linkage, causing the steering wheel to shake back and forth. In some instances, shimmy can become severe enough to make the driver lose control of the vehicle. Listed below are some of the causes of wheel shimmy.

    A. Wheel and tire imbalance

    B. Excessive wheel and tire runout

    C. Uneven tire pressure

    D. Badly or abnormally worn tires

    E. Defective tires

    F. Wheels that are severely out of alignment

    G. Defective steering stabilizer

    H. Tires and wheels that are too large for the vehicle

    I. Misaligned front-wheel-drive axles

III. Rough or damaged wheel bearings usually produce a low rumbling or growl at slow speeds. At higher speeds, rough wheel bearings will often make a howling or whining sound. Wheel bearing noise will usually increase and decrease as the steering is turned from side to side.

(NOTE: Certain types of pavement and uneven or unusual tire wear can produce noise similar to wheel bearing noise.)

IV. Wander (also referred to as directional instability) is a problem that requires the driver to make constant steering corrections to keep the vehicle in a straight path. Listed below are some of the causes of wander.

A. Low or uneven tire inflation

B. Badly worn tires

C. Incorrect front-wheel alignment

D. Incorrect rear-wheel alignment on front-wheel-drive vehicles

E. Incorrect steering gear adjustment

F. Loose wheel bearings

G. Worn steering pads

V. Lateral pull causes the vehicle to pull to one side as the car is driven straight on a level road. There are two types of lateral pull. One type occurs when the vehicle is in motion. The other type occurs only during braking. Lateral pull that occurs only during braking indicates a brake or suspension problem. Listed below are some of the causes of lateral pull.

A. Defective radial tire (one of the leading causes of pull)

B. Uneven tire pressure

C. Malfunction in the power steering control valve or power cylinder

D. Incorrect wheel alignment

E. Dragging brake

F. Broken or weak rear spring

VI. Hard steering simply means that a greater-than-normal effort is required to turn the steering wheel. Listed below are some of the causes of hard steering.

A. Steering gear adjustment too tight

B. Incorrect wheel alignment

C. Low tire pressure

D. Low or incorrect steering gear lubricant

E. Inadequate steering and/or suspension joint lubrication

VII. After the steering wheel is turned, it should be inclined to return to the straight-ahead position on its own. Poor steering return means that the steering wheel has difficulty returning to the straight-ahead position after a turn. Listed below are some of the causes of hard steering.

  A. Steering gear adjusted too tightly

  B. Incorrect wheel alignment (especially excessive positive caster)

  C. Lack of steering linkage or suspension lubrication

  D. Binding in steering column

VIII. Procedures for diagnosing wheel shimmy, vibration, vehicle wander and pull, and bearing noise during a road test

(**CAUTION:** Road test a vehicle only with the instructor's approval.)

  A. Drive the vehicle on a variety of road surfaces to ensure that inadequate pavement is not causing the problem.

  B. Drive the vehicle slowly (under 15 mph) in a straight line and note any wheel shimmy. Watch the steering wheel for any back-and-forth movement. Note any lateral shaking in the vehicle body.

  C. While driving slowly (under 15 mph), listen for any wheel bearing noise. Steer from side to side while driving. Note any increase in noise. Note the wheel from which the noise comes.

  D. Slowly accelerate to highway speed. Note any shimmy during acceleration.

  E. Front-wheel-drive axle shaft misalignment may cause shimmy to occur at a certain speed.

  F. During the road test, remember that a vibration may occur at any speed up to and including highway speed. Note what parts of the car seems to be vibrating. If the steering wheel, hood, dash, etc. are vibrating, the problem is likely caused by improper runout of the front wheel and tire or improper balance. If the vibration seems to move through the vehicle seat and body, the problem is likely in the rear wheel and tire.

  G. Power train vibration problems can sometimes mislead the technician. The below procedure can be used to diagnose vibration more precisely.

    1. Increase speed past the point at which the vibration occurs. Release the accelerator and carefully slip the transmission selector into neutral.

    2. Allow the vehicle to coast until it reaches the speed at which the vibration occurs. If the vibration does not change, the cause is probably in the tires, wheels, or suspension.

      a. If the vibration stops or changes noticeably while the vehicle is coasting in neutral, the problem is likely in the drive line.

      b. If the vibration increases or persists with increasing speed, the problem could be in the tires, wheels, drums, or rotors.

c. If the problem disappears as speed increases, the problem may involve tire and wheel runout.

H. Listen for wheel bearing noise at highway speed. At highway speed, defective wheel bearings will usually whine.

(**CAUTION:** When driving at highway speed, do not turn the steering wheel rapidly from side to side as in the low-speed test.)

I. Following the procedure outlined below, determine if the vehicle wanders.

1. While driving straight, allow the steering wheel to move on its own.

   (**CAUTION:** Never completely let go of the steering wheel.)

2. If the vehicle wanders to one side, return the vehicle to its straight path. After relaxing the grip again, see if the vehicle wanders to the other side.

3. If the vehicle steering constantly has to be corrected to the right and left, the problem is wander.

4. If the car leads to the same side every time the steering is corrected, the problem is lateral pull.

   (NOTE: If wander is detected, drive the vehicle on different road surfaces. Some surfaces, such as those with a crown, may cause the vehicle to wander.)

J. Drive the vehicle on a flat, level surface and note any lateral pull. Lateral pull is characterized by a constant pull in the same direction. Carefully apply the brakes to see if the pull occurs only when braking.

K. During the road test, note any hard steering or poor steering return. Some vehicles are designed to steer harder than others; however, excessively hard steering should be obvious. The steering should always return to the straight-ahead position when coming out of a turn.

(NOTE: Though a road test usually cannot provide a final diagnosis, the information obtained during the test can help the technician gain a better idea of the nature of the problem. The symptoms noted during a road test can be compared to service manual diagnostic charts.)

(NOTE: The technician should always be aware that steering and suspension problems can be caused by relatively simple problems such as the following: excessive or uneven tire wear; incorrect air pressure in tires; radial tire pull; and lack of steering and suspension lubrication.)

AS1-L1-UXVII

MODULE: STEERING AND SUSPENSION SYSTEMS

DIAGNOSING VARIOUS STEERING, SUSPENSION, AND WHEEL ALIGNMENT PROBLEMS

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. What term is used to describe the rapid shaking of a vehicle as it is moving?

2. What term is used to describe the back and forth shaking of the vehicle's front wheels as it is moving?

3. What term is used to describe the condition that causes the driver to make constant steering corrections?

4. What term is used to describe greater-than-normal effort required to turn the steering wheel?

5. What term is used to describe the failure of the steering wheel to return to the straight-ahead position after a turn?

6. Name four relatively simple problems that can interfere with steering and suspension operation.

MODULE: STEERING AND SUSPENSION SYSTEMS

DIAGNOSING VARIOUS STEERING, SUSPENSION, AND WHEEL ALIGNMENT PROBLEMS

(ANSWER SHEET)

1. Vibration
2. Shimmy
3. Wander or directional instability
4. Motion, braking
5. Poor steering return
6. Excessive or uneven tire wear, tire inflation, radial tire pull, lack of steering and suspension lubrication

MODULE: STEERING AND SUSPENSION SYSTEMS

ROAD TESTING A VEHICLE FOR STEERING, SUSPENSION, AND WHEEL ALIGNMENT PROBLEMS

Equipment:

Pen
Notebook

(**CAUTION:** Always obtain instructor's approval before conducting a road test. Conduct the road test in an area with little or no traffic. Never exceed the legal speed limit during the road test. Always wear safety belts. An assistant should record all observations made during the road test. Do not attempt to drive and record results at the same time.)

Procedure:	Evaluation 3 2 1 N
1. Following the procedure outlined below, road test the vehicle for shimmy.	_ _ _ _

a. Slowly drive the vehicle in a straight line and observe for shimmy.

b. Slowly accelerate to highway speed while noting any shimmy.

c. Have an assistant record the results of the shimmy test.

2. Following the procedure outlined below, road test the vehicle for vibration.	_ _ _ _

a. Drive the vehicle at highway speed and note any vibrations.

b. Vary speed and note if vibration increases, decreases, or changes in quality. If the vibration increases or persists with increasing speed, the problem may be imbalance of tires, wheels, drums or rotors. If the problem disappears with increasing speed, the problem may be tire and wheel runout.

c. If vibration is noted, drive past the speed at which the vibration occurs, release the accelerator, and carefully slip the transmission selector into neutral. If the vibration stops, the problem is likely in the drive line.

d. Coast down through the speed where the vibration occurs. If the vibration does not change, the cause is probably in the tires, wheels, or suspension. If the vibration does stop or change when the vehicle is coasting in neutral, the problem is likely in the drive line.

e. Have an assistant record the results of the vibration test.

3. Following the procedure outlined below, road test the vehicle for wander. __ __ __ __

   a. Relax hands on the steering wheel while driving straight.

   b. If the vehicle leads to one side, correct the steering and note if the vehicle leads to the other side. If the vehicle constantly has to be corrected to the right and left, the problem is wander.

   (NOTE: If the vehicle leads to the same side after every correction, the problem is lateral pull. The test for lateral pull is described below.)

   c. If wander or lateral pull is detected, drive the vehicle on different road surfaces to make sure that an irregular road surface is not causing the problem.

   d. Have an assistant record the results of the wander test.

4. Following the procedure outlined below, road test the vehicle for lateral pull. __ __ __ __

   a. Drive the vehicle on a flat, level surface and note any lateral pull. Lateral pull is characterized by the vehicle leading in the same direction.

   b. If pull is detected, drive the vehicle on a variety of road surfaces to make sure the surface is not pulling the vehicle.

   c. Carefully apply the brakes to see if the pull occurs only when braking.

   d. Have an assistant record the results of the lateral pull test.

5. Following the procedure outlined below, road test the vehicle for excessive steering effort or poor steering return. ____

   a. Drive the vehicle on a flat, level surface and make several turns to both the left and the right.

   b. The effort required to steer the vehicle should not be excessive. Steering should be smooth. The steering should always return to the straight-ahead position when the vehicle is coming out of a turn.

   c. Have an assistant record the results of the steering effort test.

6. Following the procedure outlined below, road test the vehicle for wheel bearing noise. ____

   a. Drive the vehicle at a slow speed and steer it from side to side in order to load the wheel bearings on both sides of the vehicle. Listen for bearing noise.
   b. Note any increase in noise. Note the wheel from which the noise came. If bearing noise is detected, drive on different types of road surfaces to eliminate road surface conditions as a source of the noise.

   c. Have an assistant record the results of the bearing noise test.

7. If any problems were detected during the road test, diagnose what the problem might be. Record the diagnosis. ____

   (NOTE: Use the diagnosis chart from the appropriate service manual to aid in diagnosis.)

Average of above evaluations* ____

(*This average is a partial evaluation for Competency U1. Final evaluation for U1 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency U1 by averaging the evaluations of JS1-L2-UXV, JS1-L2-UXVI, and JS1-L1-UXVII.

	Evaluation			
	3	2	1	N
JS1-L2-UXV	___	___	___	___
JS1-L2-UXVI	___	___	___	___
JS1-L1-UXVII	___	___	___	___
Final evaluation for Competency U1	___	___	___	___

MODULE: STEERING AND SUSPENSION SYSTEMS

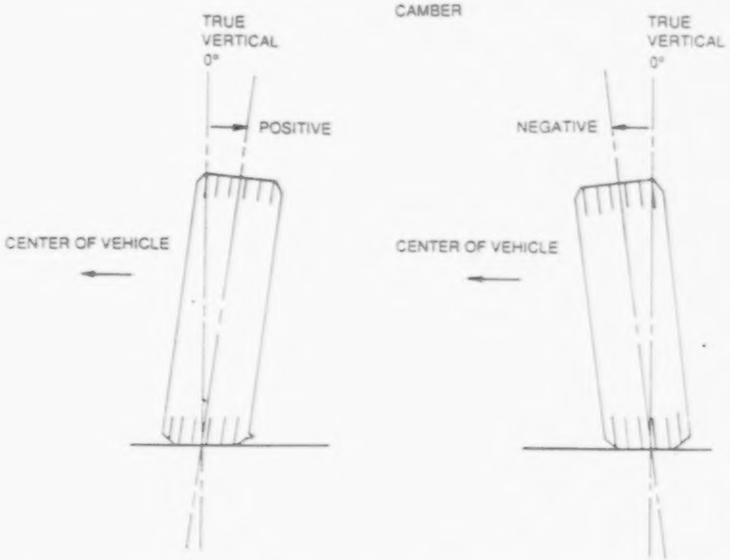
UNIT XVII: WHEEL ALIGNMENT AND STEERING AND SUSPENSION DIAGNOSIS

LESSON 2: PRINCIPLES OF WHEEL ALIGNMENT

I. Wheel alignment is the proper positioning of suspension and steering components. Wheel alignment prevents such problems as wandering and thus improves vehicle handling. Wheel alignment minimizes slipping and scuffing of the tires and thus reduces tire wear.

II. Wheel alignment angles

A. Camber is the inward or outward tilting of the wheels from a true vertical position. Positive camber refers to wheels that are tilted out at the top, causing the wheels to be further apart at the top than at the bottom. Negative camber refers to wheels that are tilted in at the top, causing the wheels to be closer at the top than at the bottom.



1. A vehicle is normally set with a slight positive camber (a slight outward tilt at the top). When the vehicle is loaded and rolling down the road, the wheels tend to move inward at the top and thus are brought into a vertical position. If the camber is set at zero (truly vertical), the top of the wheels would tilt inward (negative camber) as the vehicle moves.

2. The purposes of camber are listed below.

   a. Camber puts the point at which the tire contacts the road at or near the center of the tire tread.

   b. Camber provides for easy steering by allowing the vehicle weight to be carried by the inner wheel bearing and spindle assembly.

   c. Camber prevents tire wear.

d. Camber can be used to compensate for road crown.

3. The effects of incorrect camber are listed below.

a. Incorrect camber causes excessive wear on suspension components, particularly ball joints and wheel bearings.

b. Incorrect camber causes excessive wear on one side of the tire tread.

(NOTE: Excessive negative camber will cause wear on the inside of the tire tread. Excessive positive camber will cause wear on the outside of the tire tread.)

c. Excessive unequal camber will cause the vehicle to pull to one side.

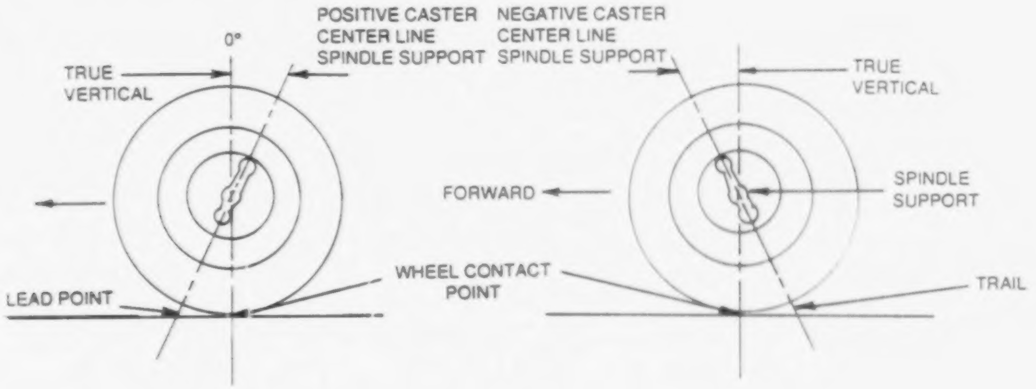
(NOTE: The vehicle will pull toward the side with the most positive camber.)

(NOTE: When possible unequal camber should be used to compensate for road crown. The spread between the camber readings between the two wheels should not exceed 1/2 of a degree.)

4. Though camber is adjustable on most vehicles, it is not adjustable on some front-wheel-drive vehicles.

5. Camber is measured by the number of degrees that the wheel centerline is tilted away from a truly vertical position.

B. Caster is the backward or forward tilt of the ball joints or strut from a truly vertical position. The backward tilt of the ball joints or strut is called positive caster while the forward tilt is called negative caster.


POSITIVE CASTER CENTER LINE SPINDLE SUPPORT
NEGATIVE CASTER CENTER LINE SPINDLE SUPPORT
0°
TRUE VERTICAL
TRUE VERTICAL
FORWARD
SPINDLE SUPPORT
WHEEL CONTACT POINT
LEAD POINT
TRAIL

1. Caster has little to do with tire wear. However, caster allows for directional control of the vehicle by causing the front wheels to stay in the straight-ahead position or return to the straight-ahead position when coming out of a turn. Caster also can be used to offset road crown.

2. The effects of incorrect caster

    a. Too much positive caster or too little negative caster results in hard steering, shimmy, and the transfer of road shock to the driver.

    b. Too little positive caster or too much negative caster results in high-speed instability and wander and weave.

    c. Excessive unequal caster causes the vehicle to pull toward the side of the least positive or most negative caster.

    (NOTE: Unequal caster can be used to offset road crown.)

    (NOTE: In order to compensate for road crown, adjust the caster so the right side has slightly more positive caster with a maximum spread of 1/2 of a degree to 3/4 of a degree between the two sides.)

3. In order to maintain good steering return, vehicles with power steering need more positive caster than those with manual steering. Cars equipped with manual steering need less positive caster to ease steering effort.

4. Caster is measured by the number of degrees the ball joints or struts are tilted from a truly vertical position. Caster is usually adjustable on rear-wheel-drive vehicles but is seldom adjustable on front-wheel-drive vehicles.

C. Steering axis inclination (SAI) (also called ball joint or kingpin inclination)

1. SAI is a nonadjustable, built-in alignment angle. SAI is an angle that has much in common with caster. Like caster, SAI affects the handling characteristics of the vehicle.

2. The purposes of steering axis inclination are listed below.

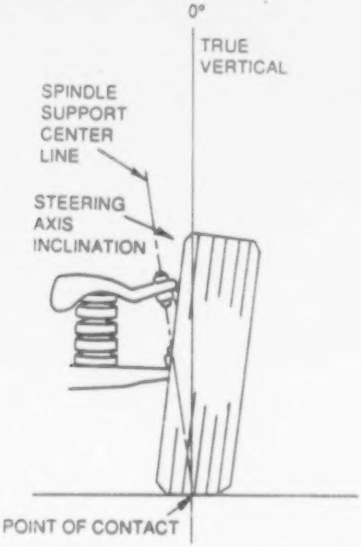
    a. To distribute the weight of the vehicle more nearly under the road contact of the tire

    b. To reduce the need for excessive camber

    c. To provide a pivot point about which the wheel will turn and produce easy steering

    d. To aid steering stability

3. Both SAI and caster are aligned with the tilt of the steering axis (the imaginary line through either the lower and upper ball joints or the lower ball joint and the top of the strut) as viewed from the side of the wheel. SAI is the tilt of the steering axis as viewed from the front of the vehicle.

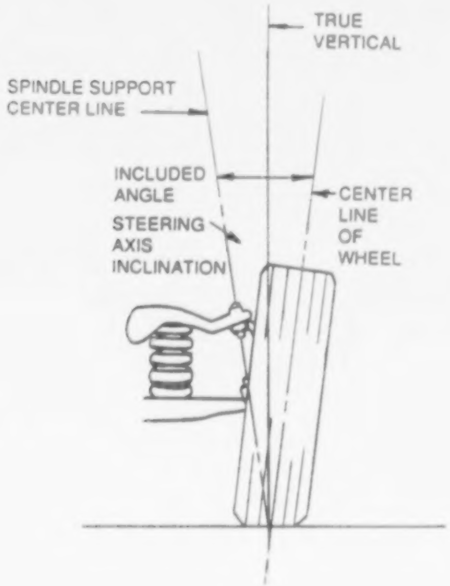


4. SAI is also similar to camber in that both angles align with the position of the wheels in relation to the chaise. Incorrect SAI can prevent the proper adjustment of camber. Incorrect SAI is also an indication of bent or damaged control arms, ball joints, steering knuckles, or vehicle frame.

5. The point at which the imaginary SAI line intersects the road surface affects vehicle steering effort and stability. If an imaginary centerline through the ball joints were vertical, it would intersect the road surface some distance inward of the point at which the tires contact the road. In this arrangement, the effort required to steer the wheel would be high because the full travel contact surface would turn sideways to the actual direction of travel. This would result in high turning effort and excessive tire wear. With increased SAI, the point of intersection is close to the center of the tire tread contact area. Since the tires turn about this center, there is less scrubbing action when the wheels are turned. Steering effort and tire wear are, therefore, reduced.

6. The distance between the point at which the SAI and the wheel centerline intersect the ground is called the scrub angle. If the pivot point is inside the tire centerline contact point, the pivot point is called the positive scrub radius. If the pivot point is outside the tire centerline contact point, the pivot point is then called the negative scrub radius. The amount and type of scrub radius can only be determined by the vehicle manufacturer.

D. Included angle is the camber angle combined with the SAI angle. The included angle determines the point of intersection of the wheel and ball joint centerlines.



E. Toe

1. Toe is a measurement of the difference in distance between the front extension of the tires to the rear extension of the tires. The purpose of toe is to achieve directional stability while the vehicle is moving. Toe is an adjustable angle and a tire wear angle. Toe is measured in fractions of inches, millimeters, or degrees.

2. The condition called "toe in" occurs when the distance between the front of the wheels is less than the distance between the back of the wheels. The condition called "toe out" occurs when the distance at the front of the wheels is greater than at the back of the wheels.

3. Rear-wheel-drive vehicles are usually set slightly toe in because the force created as the vehicle rolls forward tends to force the front of the tires outward. Many front-wheel-drive vehicles are set with a slight toe out because the tires tend to move together at the front as the vehicle rolls forward.

4. The effects of incorrect toe

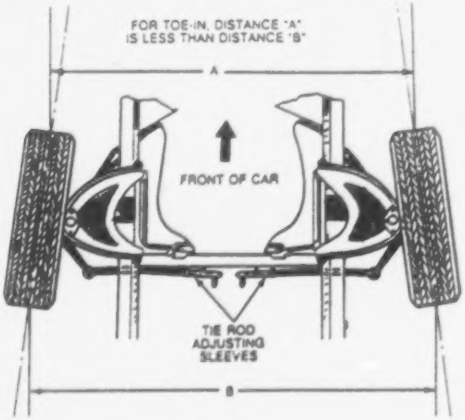
    a. Excessive toe causes feathered tire wear.

    b. Excessive toe causes tires to squeal during cornering.

    c. Too much toe in causes either feathered wear or wear to the outside of the tire located on the right axle.

d. Too much toe out causes either feathered wear or wear to the inside of the tire located on the left axle.

(NOTE: A vehicle set with zero toe will wander.)

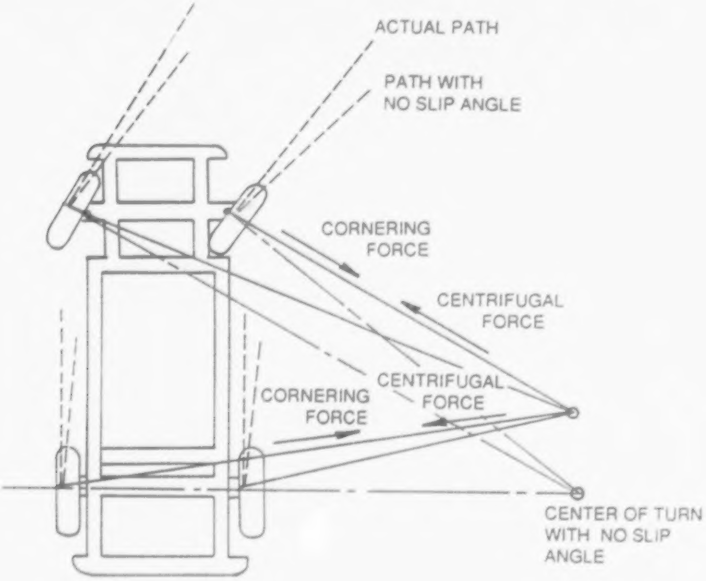

FOR TOE-IN, DISTANCE "A" IS LESS THAN DISTANCE "B"
A
FRONT OF CAR
TIE ROD ADJUSTING SLEEVES
B

F. Toe out on turns (also called front-wheel turning angle or turning radius)

1. Toe-out on turns is the difference in angles between the two front wheels and the vehicle frame during a turn. Toe out on turns is usually a non-adjustable angle that controls the tracking of the front wheels during turns. Toe out on turns is used to minimize tire wear while cornering.

2. The inner wheel follows a smaller radius than the outer wheel when the vehicle is rounding a curve. The inner wheel axle, therefore, must be at a sharper angle to the vehicle frame than the outer wheel axle. The inner wheel is toed out a greater distance. Toe out on turns is achieved by the inward angle of the steering knuckle arms at the point where they attach to the steering linkage.

3. Toe out on turns is adjustable on some vehicles; however, incorrect toe out on turns often indicates that a suspension component is bent or broken.


ACTUAL PATH
PATH WITH NO SLIP ANGLE
CORNERING FORCE
CENTRIFUGAL FORCE
CENTRIFUGAL FORCE
CORNERING FORCE
CENTER OF TURN WITH NO SLIP ANGLE

4. If the toe out on turns is incorrect, the tires will wear excessively during cornering. This excessive wear will be evidenced by a squealing of the tires during cornering. The squeal will occur even at low speeds.

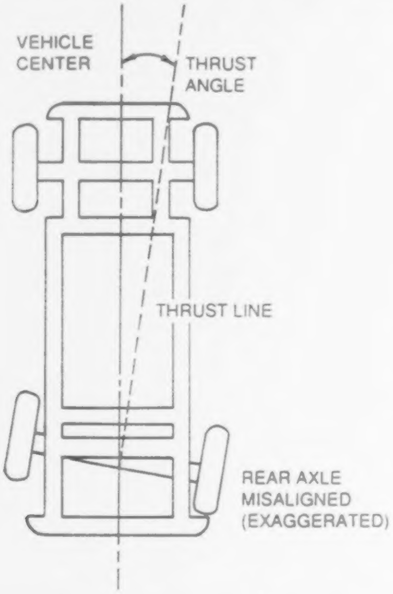
G. Thrust angle

1. Thrust angle (line) is the direction that the vehicle's rear wheels would travel if unaffected by the front wheels. The thrust angle determines the vehicle's tracking. An incorrect thrust angle will cause the vehicle to appear to be running (tracking) sideways down the road. This sideways movement is called "dog tracking."

2. If there is no misalignment, the thrust angle (line) should be the same as the vehicle centerline. The centerline is an imaginary line through the center of the vehicle. (The vehicle is thought of as being constructed upon the centerline.)

3. The vehicle frame should be parallel to the centerline. The angles formed by the axles intersecting the vehicle centerline should be 90-degree angles. If the rear wheels are square with each other and the rear axle is at right angles with the centerline, the correct thrust angle will be zero.

4. The angle formed between the vehicle centerline and the thrust line is called the thrust angle. Incorrect thrust angle will cause the vehicle to pull to one side. Incorrect thrust angle can also affect directional stability and braking control.



5. The thrust angle is not adjustable on most rear-wheel-drive vehicles. Improper thrust angle is usually caused by broken spring tie bolts or broken spring leaves causing the axle assembly to shift. Also, frame damage resulting from an accident could be the cause. On front-wheel-drive vehicles, incorrect thrust angle is more common. The rear toe and camber is adjustable on many of these vehicles. Adjustable rear toe and camber allows for easier correction of the problem if spring, axle, or frame damage is not the cause.

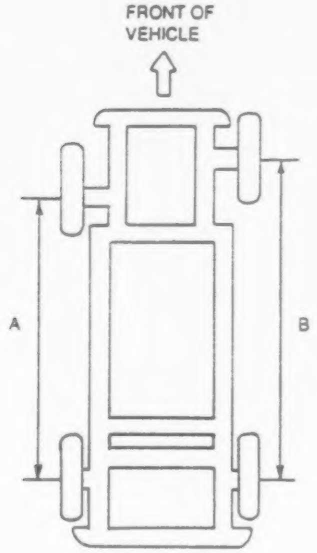
6. On front-wheel-drive vehicles, improper thrust angles could be corrected by aligning the rear wheels.

(NOTE: Newer wheel aligning equipment capable of measuring alignment at all four wheels can detect improper thrust angle.)

H. Setback

1. Setback is a condition in which one of the vehicle's wheels sets further toward the rear of the vehicle than the wheel on the other side. Excessive setback is usually the result of a frontal impact that pushes one wheel toward the rear of the vehicle.

2. Setback can be measured on most modern alignment equipment. Most vehicles can tolerate a slight amount of setback without any problems. Because setback is not adjustable, excessive setback is corrected by replacing components or straightening the vehicle frame.



I. Before making any alignment adjustments, the vehicle's ride height should be checked and corrected. If the ride height is incorrect, the other wheel alignment angles will be thrown off. Incorrect ride height can be adjusted on some torsion bar suspension systems, but otherwise springs or other suspension parts must be replaced to correct ride height.

(NOTE: See Unit IX of this module for details on vehicle ride height.)

MODULE: STEERING AND SUSPENSION SYSTEMS

WHEEL ALIGNMENT PRINCIPLES

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. What term is used to describe the inward or outward tilt of the top of the front wheels?

2. What term is used to describe the rearward or forward tilt of the ball joints or strut?

3. What term is used to describe the difference in distance between the front of the tires and the rear of the tires?

4. What measurement should be taken before any alignment adjustment is made?

5. What is the result of excessive thrust angle?

6. What is the effect of incorrect camber?

MODULE: STEERING AND SUSPENSION SYSTEMS

WHEEL ALIGNMENT PRINCIPLES

(ANSWER SHEET)

1. Camber
2. Caster
3. Toe
4. Ride height
5. Incorrect thrust angle will cause the vehicle to pull to one side. Incorrect thrust angle can also affect directional stability and braking control.
6. Incorrect camber causes excessive wear on suspension components, particularly ball joints and wheel bearings. Incorrect camber causes excessive wear on one side of the tire tread. Excessive unequal camber will cause the vehicle to pull to one side.

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVII: WHEEL ALIGNMENT AND STEERING AND SUSPENSION DIAGNOSIS

LESSON 3: MEASURING AND CORRECTING WHEEL ALIGNMENT

I. Wheel alignment equipment

(NOTE: The design and complexity of wheel alignment equipment can vary greatly. The equipment may consist of either simple gauges or complex electronic machines.)

A. Some electronic wheel alignment equipment has a sensor at each wheel. These sensors send signals to a panel or screen. The screen shows the misalignment and helps guide the technician through the adjustment procedures. The technician enters the alignment specifications into the machine. The technician can then print out a sheet showing alignment specifications, actual readings before alignment, and readings taken after alignment is completed.

B. Turntables are sometimes used during wheel alignment to allow the front wheels to turn easily during the procedure. The turntables are marked in degrees. The vehicle is placed on the turntables with the wheels straight ahead. The turntables are then set on the zero degree mark. The wheels are then turned to check caster and toe out on turns.

C. Wheel alignment may be performed by placing the vehicle on a level floor with the front wheels resting on turntables. (The vehicle is not raised.) For this procedure, it is very important that the vehicle rests on a level surface. If wheel alignments are performed in this manner, it may be difficult to reach adjustment devices.

D. The most convenient way of doing wheel alignment is through the use of a special hoist equipped with turntables. The hoist raises the vehicle on a level surface and allows the technician access to the adjustments under the vehicle.

(NOTE: Many special tools are designed to assist the technician in adjusting wheel alignment.)

II. Procedures for making pre-alignment checks

(NOTE: The procedure below involves tasks that should be done prior to measuring or adjusting alignment.)

A. Make sure tires are at proper inflation pressure.

B. Make sure all tires are the same size.

C. If necessary, check and adjust wheel bearing adjustment.

D. Inspect for loose, worn, or damaged steering and front and rear suspension components.

E. Test ball joint condition.

F. Check for wheel and tire assembly runout.

G. Check and adjust steering gear adjustment.

H. Check for excessive vehicle loads. Remove any excessive loads, if found.

I. Check and correct vehicle ride height.

J. Remove any dirt and mud from the wheels, tires, or suspensions.

K. Check manufacturer's alignment procedures for unique instructions. Some manufacturers require that the gas tank be full during alignment. Others require that weight be added to the car to simulate passenger weight.

III. Interrelation of alignment angles

A. The various alignment angles are interrelated; therefore, alignment angles will have to be adjusted in a specific order. The manufacturers of alignment equipment usually provide a manual which gives the order for checking and adjusting the various angles.

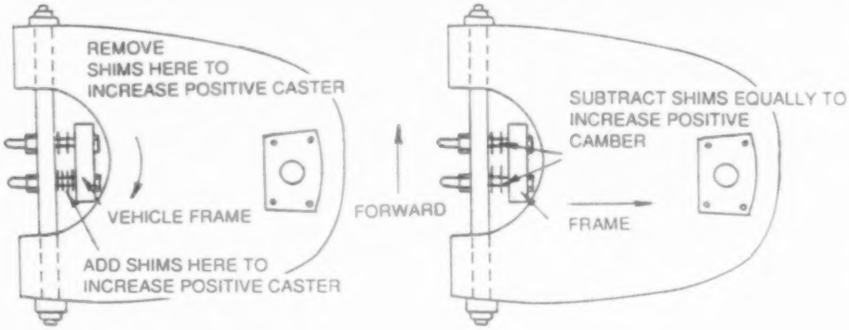
B. Front wheel angles are usually checked in the following order: 1) camber, 2) caster, 3) toe, 4) SAI, and 5) toe-out on turns. This order ensures that an angle that has been properly set is not changed. No matter what the order of angle adjustment is, always recheck the other angles after changing one.

(NOTE: Due to the variations in procedures for various types of alignment equipment, this unit will deal only with procedures for changing adjustable angles. See the equipment manufacturer's instruction manual for directions on using a particular alignment machine.)

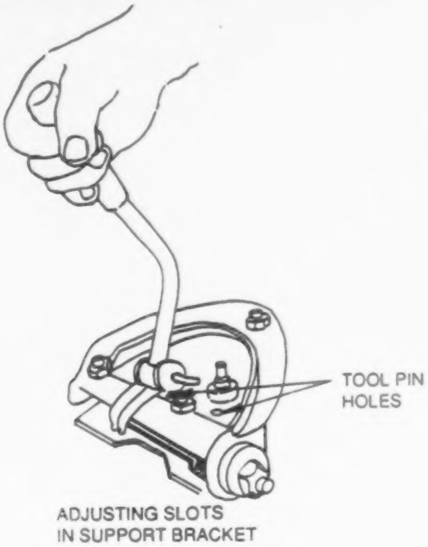
(NOTE: Never correct alignment by heating or bending steering or suspension components. If corrections cannot be made through normal adjustment procedures, the defective parts must be replaced.)

IV. Procedures for adjusting front-wheel camber

A. Depending on the suspension design, a variety of methods must be used to adjust front-wheel camber. One common adjustment method involves adding or removing shims from the upper control arm shaft mounting points. Moving an equal number of shims on both the front and rear of the arm changes camber without affecting caster.


REMOVE SHIMS HERE TO INCREASE POSITIVE CASTER
VEHICLE FRAME
ADD SHIMS HERE TO INCREASE POSITIVE CASTER
FORWARD
SUBTRACT SHIMS EQUALLY TO INCREASE POSITIVE CAMBER
FRAME

B. Slotted holes at the upper control arm mounting points can also be used to adjust front-wheel camber. Moving both the front and rear of the arm an equal distance in the same direction will change camber without affecting caster.



C. Vehicles that have the spring on the upper control arm usually have an eccentric cam adjustment, which allows for the adjustment of front-wheel camber.

(NOTE: Eccentric cam adjustment or slotted hole adjustment is used at the lower attaching point of some MacPherson strut vehicles.)

D. Eccentric cam adjustment is also found at the upper control arms of some vehicles with short and long arm suspension. When the cam adjustment is moved an equal distance to the front and rear, camber will be changed without affecting caster.

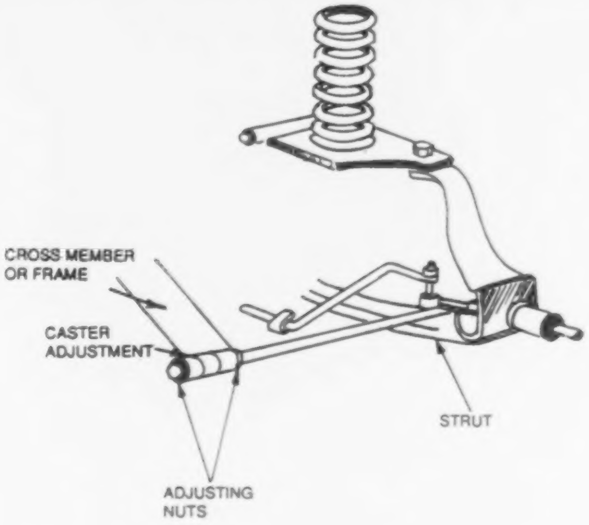
V. Procedures for adjusting front-wheel caster

A. Many of the procedures for adjusting camber apply to adjusting caster. When changing caster or camber, be careful to change only those which are not within specifications.

B. As in front-wheel camber adjustment, front-wheel caster can be adjusted by adding or removing shims at one end of the upper control arm. However, adding or removing shims will also change camber. Removing shims from one end and adding the same shims to the other end should change caster without affecting camber.

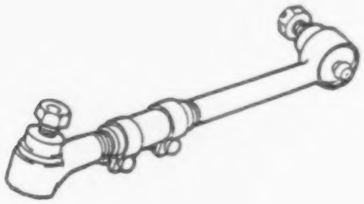
C. Slotted adjustment and eccentric cam adjustment on the upper control arm allows for adjustment of front-wheel caster as well as front-wheel camber.

D. Vehicles with the spring on the upper control arm as well as some MacPherson strut vehicles are equipped with adjustable strut rods to correct caster. Changing the strut rod adjustment moves the lower control arm forward or backward to change caster.



VI. Procedures for adjusting front-wheel toe

A. Front-wheel toe is changed by using the adjusting sleeve to increase or decrease the tie rod length. The procedure is outlined below.



1. Center the steering wheel with the front wheels pointing straight ahead.

   (NOTE: If the vehicle is equipped with power steering, start the engine and move the steering wheel back and forth several times to center the steering. Turn off the engine and lock the steering wheel in the straight-ahead position with a steering wheel locking clamp. A few manufacturers specify that the engine be kept running while the toe is being adjusted.)

2. Loosen the tie rod clamp bolts and adjust toe.

   (NOTE: Key the tie rods about the same length.)

3. Tighten the clamp bolts to specification. Make sure tie rods are centered in their bowls. Do not allow the gap in the sleeve clamp to line up with the gap in the sleeve. Position clamps as instructed by the manufacturer.

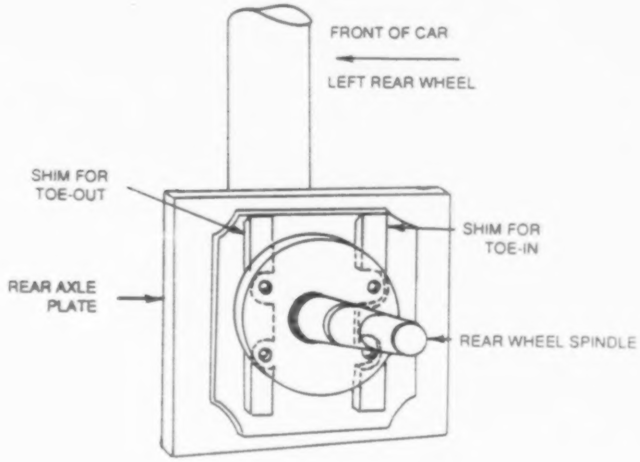
B. Other methods for adjusting toe involve the use of either an optical system or a computer-assisted toe adjuster. Both of these machines adjust toe in relation to the vehicle's centerline and, therefore, allow for the most accurate toe adjustment.

VII. Procedures for rear-wheel alignment

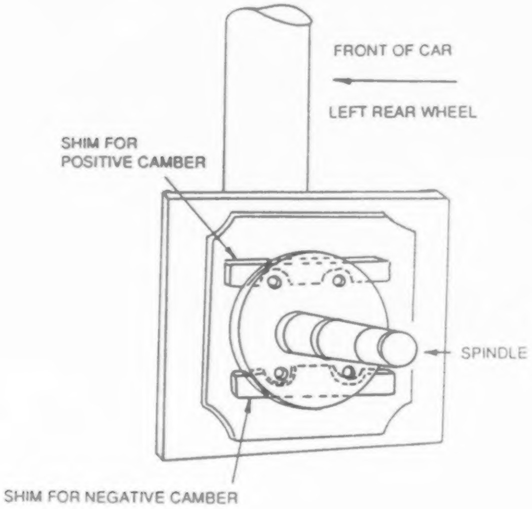
A. Rear-wheel alignment can be performed on a machine designed to align all four wheels at once. Rear-wheel alignment can also be performed on a two-wheel alignment rack. The vehicle is simply backed onto the two-wheel alignment rack.

B. Camber and toe are adjustable on the rear wheels of many front-wheel-drive vehicles. One common method for adjusting camber and toe on the rear wheels is done by removing the wheel spindle and installing selective shims between the spindle and axle.

1. Installing shims in the front or rear of the spindle changes toe.


FRONT OF CAR
LEFT REAR WHEEL
SHIM FOR TOE-OUT
SHIM FOR TOE-IN
REAR AXLE PLATE
REAR WHEEL SPINDLE

2. Installing shims on the upper or lower side of the spindle changes the camber.


FRONT OF CAR
LEFT REAR WHEEL
SHIM FOR POSITIVE CAMBER
SPINDLE
SHIM FOR NEGATIVE CAMBER

C. Eccentric cams, which are attached to the interconnecting points of the lower control arms, also provide a means for adjusting toe on the rear wheels of front-wheel-drive vehicles. The cams adjust the length of the control arms to change toe.

VIII. Four-wheel alignment

A. Four-wheel alignment ensures that all four wheels are parallel to each other and perpendicular to the imaginary centerline of the vehicle. In past years, vehicles with unibodies had enough front alignment adjustment to cover imperfections in the rear axle. Today's vehicles do not have adequate adjustment.

B. Four-wheel alignment provides for less rolling resistance, better fuel economy, and longer tire life. Four-wheel alignment also causes the vehicle to drive and track straight ahead when the steering wheel is centered.

C. Four-wheel alignment can be performed either on two-wheel alignment equipment or four-wheel equipment.

(NOTE: If the technician uses two-wheel alignment equipment to perform a four-wheel alignment, he or she will have to take extra steps to ensure that the vehicle centerline is correct. These centerline checks are usually done automatically by four-wheel alignment equipment.)

(NOTE: If the technician uses two-wheel alignment equipment to perform a four-wheel alignment, he or she must align the rear wheels first by backing the vehicle onto the equipment.)

D. Procedure for performing a four-wheel alignment

(NOTE: The below procedure is general and will not apply to all alignment equipment or vehicles. Refer to the procedure provided by the manufacturers of the alignment equipment or the proper vehicle service manual for more specific procedures.)

1. Perform all pre-alignment procedures.
2. Set the rear camber, if necessary.
3. Set the rear toe, if necessary.
4. Set the caster and camber on one of the vehicle's front sides.
5. Set the caster and camber on the other front side of the vehicle.
6. Set the front toe.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR MEASURING AND CORRECTING FRONT-WHEEL ALIGNMENT

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual and the information provided by the manufacturer of the alignment equipment.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Outline the proper sequence for measuring front-wheel alignment angles. List all angles that the alignment equipment is capable of measuring. Record the specifications for each angle. Also record the vehicle's ride height specifications.
3. Develop a written procedure for adjusting front-wheel caster. Include the use of any special tools required.
4. Develop a written procedure for adjusting front-wheel camber. Include the use of any special tools required.
5. Develop a written procedure for adjusting front-wheel toe. Include the use of any special tools required.

MODULE: STEERING AND SUSPENSION SYSTEMS

PROCEDURES FOR MEASURING AND CORRECTING REAR-WHEEL ALIGNMENT

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written sequence for measuring rear-wheel alignment angles with available equipment. Record the specifications for each angle. Also record the vehicle's ride height specifications.
3. Develop a written procedure for adjusting rear-wheel camber. Include the use of any special tools required.
4. Develop a written procedure for adjusting rear-wheel toe. Include the use of any special tools required.

JS1-L3-UXVII

MODULE: STEERING AND SUSPENSION SYSTEMS

MEASURING AND CORRECTING FRONT-WHEEL ALIGNMENT

Equipment:

Alignment machine
Hand tools
Special tools as needed
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

   (NOTE: If the vehicle being serviced requires a four-wheel alignment, adjust the rear wheels first.)

2. Place the vehicle securely on safety stands or safely lift it with a hoist. ___ ___ ___ ___

3. Perform a pre-alignment check of the vehicle. Use the check list below to indicate if an item is "OK" or "NOT OK." ___ ___ ___ ___

Tire pressure	OK ___	NOT OK ___
Wheel bearing adjustment	OK ___	NOT OK ___
Condition of steering and suspension components	OK ___	NOT OK ___
Tire and wheel assembly runout	OK ___	NOT OK ___
Steering gear adjustment	OK ___	NOT OK ___
Excessive vehicle load	OK ___	NOT OK ___
Ball joint condition	OK ___	NOT OK ___

If any item in the above list is "NOT OK," describe the problem and recommend repair procedures in the space below.

(NOTE: If worn or loose parts are found, they must be replaced to ensure an accurate alignment. Inform the instructor if worn parts are discovered during the pre-alignment inspection.)

4. Complete AS1-L3-UXVII. Measure vehicle ride height and compare it to the specifications recorded in item 2 of AS1-L3-UXVII. _ _ _ _

Is vehicle at its proper ride height? Yes _____ No _____

(NOTE: Incorrect ride height will result in incorrect alignment. If ride height is incorrect, consult the instructor before continuing.)

5. Following the sequence developed in item 2 of AS1-L3-UXVII, measure camber and caster. Record the measurements. _ _ _ _

Left Right

Camber________________________

Caster________________________

6. Following the procedure developed in item 3 of AS1-L3-UXVII, adjust front-wheel caster to specifications. _ _ _ _

(NOTE: Make sure alignment adjustments are made in the sequence prescribed by the manufacturer. Making adjustments in the wrong sequence can result in improper alignment.)

7. Following the procedure developed in item 4 of AS1-L3-UXVII, adjust front-wheel camber to specifications. _ _ _ _

8. Measure toe and record measurements. _ _ _ _

9. Following the procedure developed in item 5 of AS1-L3-UXVII, adjust front-wheel toe to specifications. _ _ _ _

10. Recheck all angles. Correct any angles that still do not meet specifications. _ _ _ _

(NOTE: The correction of one adjustment angle may affect some other adjustment angles. Consider the proper adjustment sequence when making any adjustments.)

11. Record any angles that could not be adjusted to specifications. Indicate what problem may be preventing proper adjustment. — — — —

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency U2. Final evaluation for U2 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency U2 by averaging the evaluations of JS1-L1-UIX and JS1-L3-UXVII. Use the spaces provided below.

	Evaluation 3 2 1 N
JS1-L1-UIX	— — — —
JS1-L3-UXVII	— — — —
Final evaluation for Competency U2	— — — —

MODULE: STEERING AND SUSPENSION SYSTEMS

MEASURING AND CORRECTING REAR-WHEEL ALIGNMENT

Equipment:

Alignment machine
Hand tools
Special tools as needed
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

   (NOTE: If the vehicle being serviced requires a four-wheel alignment, adjust the rear wheels first.)

2. Place the vehicle securely on safety stands or safely lift it with a hoist. ___ ___ ___ ___

3. Perform a pre-alignment check of the vehicle. Use the check list below to indicate if an item is "OK" or "NOT OK." ___ ___ ___ ___

Tire pressure	OK ____	NOT OK ____
Wheel bearing adjustment	OK ____	NOT OK ____
Condition of suspension components	OK ____	NOT OK ____
Tire and wheel assembly runout	OK ____	NOT OK ____
Steering gear adjustment	OK ____	NOT OK ____
Vehicle load	OK ____	NOT OK ____

If any item in the above list is "NOT OK," describe the problem and recommend repair procedures in the space below.

(NOTE: If worn or loose parts are found, they must be replaced to ensure an accurate alignment. Inform the instructor if worn parts are discovered during the pre-alignment inspection.)

4. Complete AS2-L3-UXVII. Measure vehicle ride height and compare it to the specifications recorded in item 2 of AS2-L3-UXVII. _ _ _ _

Is vehicle at its proper ride height? Yes _____ No _____

(NOTE: Incorrect ride height will result in incorrect alignment. If ride height is incorrect, consult the instructor before continuing.)

5. Following the sequence developed in item 2 of AS2-L3-UXVII, measure all rear-wheel alignment angles. Record the measurements. _ _ _ _

	Left	Right
Camber		
Caster		

6. Following the procedure developed in item 3 of AS2-L3-UXVII, adjust rear-wheel camber to specifications. _ _ _ _

(NOTE: Make sure alignment adjustments are made in the sequence prescribed by the manufacturer. Making adjustments in the wrong sequence can result in improper alignment.)

7. Following the procedure developed in item 4 of AS2-L3-UXVII, adjust rear-wheel toe to specifications. _ _ _ _

8. Check vehicle thrust angle if the alignment equipment allows for it. Record results. _ _ _ _

9. Recheck all angles. Correct any angles that still do not meet specifications. _ _ _ _

(NOTE: The correction of one adjustment angle may affect some other adjustment angles. Consider the proper adjustment sequence when making any adjustments.)

10. Record any angles that could not be adjusted to specifications. Indicate what problem may be preventing proper adjustment. ____

Average of above evaluations* ____

(*This average is the final evaluation for Competency U3.)

MODULE: STEERING AND SUSPENSION SYSTEMS

UNIT XVII: WHEEL ALIGNMENT AND STEERING AND SUSPENSION DIAGNOSIS

UNIT XVII TEST

PART I. DIAGNOSING STEERING AND TIRE WEAR PROBLEMS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. Dragging brakes can cause a vehicle to vibrate at highway speeds.

____ 2. Wheel shimmy usually begins at a lower speed than other types of vehicle vibration.

____ 3. Vehicle vibrations can become severe enough to make the driver lose control of the vehicle.

____ 4. Uneven tire pressure can cause wheel shimmy.

____ 5. Wheel bearing noise causes a howling sound at low speeds.

____ 6. Uneven tire tread wear can make noise similar to that produced by defective wheel bearings.

____ 7. Wander and directional inability refer to the same problem.

____ 8. Incorrect wheel alignment can cause hard steering.

____ 9. When road testing a vehicle at highway speed, the technician should turn the steering wheel rapidly.

____ 10. Inadequate steering and/or suspension joint lubrication can cause lateral pull.

SECTION B. **Select the best answer from the five choices listed.**

____ 11. Wheel shimmy causes the steering wheel to

  a. become much harder to turn.
  b. become much easier to turn.
  c. shake back and forth
  d. lock up.
  e. do none of the above.

____ 12. Wander can be caused by

  a. loose wheel bearings.
  b. incorrect steering gear adjustment.
  c. badly worn tires.
  d. incorrect wheel alignment.
  e. all of the above.

____ 13. Lateral pull can be caused by

a. poor road conditions.
b. defective manual steering gear.
c. broken or weak shocks.
d. mixing radial and bias ply tires.
e. none of the above.

____ 14. When road testing a vehicle for alignment problems, the technician should

a. drive on a variety of road surfaces.
b. drive both at low speeds and highway speeds.
c. note any vibrations and the speed at which they occur.
d. accelerate slowly and note any shimmy.
e. do all of the above.

____ 15. In order to test for lateral pull, the vehicle should be driven on a

a. level surface.
b. rough surface
c. wet surface.
d. steep grade.
e. none of the above.

SECTION C. **Read each of the below statements made by Technicians I and II. Indicate which technician is correct by placing the appropriate letter in the blank beside each question.**

____ 16. TECHNICIAN I says that power train vibrations can sometimes be difficult to diagnose.

TECHNICIAN II says that, if a vibration problem disappears with increasing speed, the problem may be tire and wheel runout.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 17. TECHNICIAN I says that loose rear wheel bearings can cause shimmy.

TECHNICIAN II says that a dragging brake can cause the vehicle to pull.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 18. TECHNICIAN I says that a road test should be done on lightly traveled roads.

TECHNICIAN II says that a road test by itself can seldom produce a conclusive diagnosis of a wheel alignment problem.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 19. TECHNICIAN I says that wheel bearing noise is usually accompanied by excessive shimmy.

TECHNICIAN II says not to spin drive wheels faster than 35 mph when checking wheel bearing noise on front-wheel-drive vehicles.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

____ 20. TECHNICIAN I says that lateral pull occurs during rapid acceleration.

TECHNICIAN II says that lateral pull only occurs on rough pavement.

Who is right? (a) I only (b) II only
(c) both I and II (d) neither I nor II

(NOTE: The student must obtain a minimum score of ______ on Part I of the Unit XVII Test in order to receive an evaluation for Competency U1.)

PART II. SETTING CORRECT ALIGNMENT ANGLES

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 21. Setback is a condition in which one of the vehicle's wheels sets further toward the rear of the vehicle than the wheel on the other side.

____ 22. Before making any alignment measurement, the vehicle ride height should be checked and corrected.

____ 23. Setback is usually the result of a frontal impact.

____ 24. Scrub radius is the direction that a vehicle's rear wheels would travel if unaffected by the vehicle's front wheels.

____ 25. Camber is a nonadjustable angle that controls the tracking of the front wheels.

____ 26. Caster is measured in fractions of inches or millimeters.

____ 27. Tire size determines the point of intersection of the wheel and ball joint centerlines.

____ 28. Incorrect steering axis inclination (SAI) is an indication of either a bent steering knuckle or frame or damaged control arms or ball joints.

____ 29. Negative caster is the forward tilt of the ball joints or strut.

____ 30. Alignment refers to the proper positioning of suspension and steering components.

____ 31. Caster is the inward or outward tilt of the top of the wheels.

____ 32. Negative camber is the backward tilt of the ball joints or strut.

____ 33. Toe out is when the distance between the front of the tires is less than the distance between the back of the tires.

____ 34. Toe out on turns is also known as front wheel turning angle or turning radius.

____ 35. Alignment angles should be checked in the proper sequence.

____ 36. On rear wheels, a common method for adjusting camber and toe involves installing selective shims between the spindle and axle.

____ 37. An eccentric cam is used to adjust caster on vehicles with MacPherson struts.

____ 38. Toe must be set with the wheels and steering wheel pointed straight ahead.

____ 39. If possible, alignment angles should be adjusted by heating or bending components.

____ 40. Some alignment machines can check the alignment of all four wheels.

(NOTE: The student must obtain a minimum score of ______ on Part II of the Unit XVII Test in order to receive an evaluation for Competency U2.)

PART III. SETTING CORRECT CAMBER AND TOE ON REAR WHEELS

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 41. Eccentric cams, which are attached to the interconnecting points of the lower control arms, also provide a means for adjusting toe on the rear wheels of front-wheel-drive vehicles.

____ 42. Rear-wheel alignment can be accomplished by removing the wheel spindle and installing selective washers between the spindle and axle.

____ 43. Rear-wheel alignment can be performed on a two-wheel alignment rack.

____ 44. Rear-wheel camber and toe are usually adjustable on the rear wheels of rear-wheel-drive vehicles.

____ 45. Caster is not adjusted on rear wheels.

(NOTE: The student must obtain a minimum score of ______ on Part III of the Unit XVII Test in order to receive an evaluation for Competency U3.)

ANSWERS TO UNIT XVII TEST

1. t
2. t
3. t
4. t
5. f
6. t
7. f
8. t
9. f
10. f
11. c
12. e
13. e
14. e
15. a
16. a
17. b
18. c
19. d
20. d
21. t
22. t
23. t
24. f
25. f
26. f
27. f
28. t
29. t
30. t
31. f
32. f
33. f
34. t
35. t
36. t
37. f
38. t
39. f
40. t
41. t
42. t
43. t
44. f
45. t

END

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